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# EXPERIMENTAL EVALUATION OF CURSORS FOR B-2 SYNTHETIC APERTURE RADAR (SAR) APPLICATION (U)



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This technical report has been reviewed and is approved for publication.

**FOR THE COMMANDER**

Kenneth R Boff

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The purpose of the current study was to evaluate the current and two alternative cursors for B-2 Synthetic Aperture Radar (SAR) imagery application and to recommend an alternative design. This study was conducted in response to problems crewmembers are experiencing with the current cursor on the B-2 SAR display. In particular, the design of the current radar cursor (i.e., the width of the cursor bars) makes it difficult to accomplish fine cursor positioning (i.e., accurate placement of the cursor within the desired one pixel of the target.) This affects the accuracy of radar updates and impacts the precision of the navigation and bombing solutions. The experiment evaluated the current cursor and two alternative designs in terms of designation speed and accuracy. Eighteen subjects completed experimental trials in which they performed a SAR radar update procedure (i.e., identified and designated specified aim points). This procedure was conducted using simulated SAR imagery presented on a multipurpose display unit (MDU) within the Computer-Assisted Procedures Trainer (CAPT) resident at Armstrong Laboratory. The results indicated that one of the alternative cursor designs elicited significantly higher designation accuracy (mean error = 1.94 pixels) than the current cursor (mean error = 2.36 pixels) or the second alternative cursor (mean error = 2.28 pixels). Designation speed did not vary significantly across cursors. Subjective data and comments gathered from subjects supported these findings, with the most accurate alternative cursor being rated as "very effective" and the current cursor being rated as "somewhat ineffective."

**14. SUBJECT TERMS**
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## EXECUTIVE SUMMARY


### Purpose

This report documents the results of a laboratory investigation of the B-2 radar cursor and its effectiveness in terms of designation speed and accuracy as well as user acceptance. The study was conducted in response to problems crewmembers are experiencing with the current cursor on the B-2 radar display. In particular, the design of the current radar cursor (i.e., the width of the cursor bars) makes it difficult to accomplish fine cursor positioning (i.e., accurate placement of the cursor within the desired one pixel of the target.) This affects the accuracy of radar updates and impacts the precision of the navigation and bombing solutions. The purpose of this study was to evaluate the current cursor and alternative cursor designs for the B-2 SAR imagery application and to recommend an alternative design.

### Method

The experiment evaluated the current cursor and two alternative designs in terms of designation speed and accuracy. Eighteen subjects, consisting of current or previous USAF pilots or radar navigators, completed experimental trials in which they performed a radar update procedure (i.e., identified and designated specified aim points). This procedure was conducted using simulated SAR imagery presented on a multipurpose display unit (MDU) within the Computer-Assisted Procedures Trainer (CAPT) resident at Armstrong Laboratory at Wright Patterson Air Force Base, Dayton, Ohio. Each subject performed 40 experimental trials or designation events with each of the three cursors. Designation was evaluated in terms of the speed and accuracy of cursor placement. After completing the trials, subjects were asked to respond to a questionnaire addressing the following areas: (1) cursor effectiveness, (2) designation technique (3) mechanization of the cursor controller, and (4) the fidelity of the part-task simulation.

### Results

The results indicated that one of the alternative cursor designs (Cursor 2) elicited significantly higher designation accuracy (mean error = 1.94 pixels) than the current cursor (Cursor 1, mean error = 2.36 pixels) or the second alternative cursor (Cursor 3,

mean error = 2.28 pixels). Designation speed did not vary significantly across cursors, occurring approximately 17 seconds into a trial. Examination of the cursor position over the course of the trial indicated that, when performing the update procedure with the current cursor, subjects initially moved the cursor *away* from the intended designation point, before returning to the aim point and designating. When asked why they used this strategy (i.e., pulling the cursor off of the area of interest), subjects stated that the current cursor obscured important cues necessary for accurate designation. With both alternative cursors, subjects tended to move directly toward the intended designation point. In addition, analysis of cursor position over time indicated that subjects exhibited difficulty with fine positioning of all three cursors. When moving the cursor toward the intended designation point, subjects "overshot" the intended point an average of 4.8 times per trial across cursors. Subjects attributed this overshooting before designation to problems associated with the mechanization of the cursor controller which did not vary across cursors.

Subjective data and comments gathered from subjects supported these findings. Overall, subjects rated the effectiveness of the current cursor as "somewhat ineffective," whereas alternative Cursor 2 was rated as "very effective." When asked to choose which cursor they preferred, 10 subjects chose alternative Cursor 2, seven chose alternative Cursor 3, and one chose the current cursor (Cursor 1).

## Conclusion

The improved performance with Cursor 2 is attributed to its longer, thinner bars as well as its smaller center opening and its perpendicular terminators. According to subjective comments, these factors aided in determining the center of the cursor and aligning the cursor over the intended designation point. However, the cursor controller mechanization, which was not addressed in this study, was also determined to be a cause of poor designation strategy, regardless of cursor type.

# PREFACE

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## LIST OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS

| | |
|---|---|
| AFB | - Air Force Base |
| ANOVA | - Analysis of Variance |
| AL/CFHI | - Armstrong Laboratory, Crew Systems Directorate, Human Engineering Division, Crew Systems Integration Branch |
| CAPT | - Computer-Assisted Procedures Trainer |
| CEF | - Cockpit Evaluation Facility |
| CTF | - Combined Test Force |
| DTIC | - Defense Technical Information Center |
| DRLMS | - Digital Radar Landmass Simulator |
| EWO | - Electronic Warfare Officer |
| EVS | - Electro-Optical Viewing System |
| F | - Value of the F-Statistic |
| FLIR | - Forward Looking Infrared |
| MDU | - Multipurpose Display Unit |
| MSE | - Mean Squared Error |
| NAV | - Navigator |
| OSO | - Offensive Systems Operator |
| PC | - Personal Computer |
| P&ES | - Prototyping and Evaluation Station |
| RFP | - Radar Fix Point |
| RN | - Radar Navigator |
| SAIC | - Science Applications International Corporation |
| SAR | - Synthetic Aperture Radar |
| SEDATA | - Systems Engineering Design and Technical Analysis |
| SG | - Silicon Graphics |
| SIDEF | - Systems Integration Design and Evaluation Simulator |
| SPO | - System Program Office |
| USAF | - United States Air Force |
| USGS | - United States Geological Survey |
| WSO | - Weapon Systems Operator |

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# SECTION I
## Introduction

This section of the report presents an overview of the background and approach to the experiment as well as a discussion of how the alternative cursors were developed.

### Background

In June 1991, Armstrong Laboratory (AL/CFHI) at Wright Patterson Air Force Base, Dayton, Ohio, was chartered to support the B-2 System Program Office (SPO) in the development, operation and enhancement of the B-2 Cockpit Evaluation Facility (CEF). The CEF consists of an Engineering Hotbench, otherwise known as the Prototyping and Evaluation Station (P&ES); a B-2 crewstation simulator; a display prototyping development station and a government-provided secure facility. The CEF is currently being utilized to assess current and future B-2 aircraft crewstation design approaches, allowing researchers and developers to rapidly respond to a wide range of B-2 control and display-related issues. This CEF capability affords researchers the ability to develop prototype Multipurpose Display Unit (MDU) displays, evaluate displays in a semi-operational environment, and provide feedback to the B-2 SPO. The B-2 CEF represents a unique engineering capability that has been specifically designed to meet the study needs associated with the evaluation of advanced controls and displays. Rapid prototyping software, a comprehensive set of generic aircraft models, and a flexible simulation control and data collection/reduction capability are key features.

Within the context of this B-2 support, AL/CFHI was approached by the B-2 SPO who expressed the concern that B-2 crewmembers were experiencing problems with the cursor used on the radar display. In particular, the design of the current radar cursor (i.e., three pixels in width) made it difficult to accomplish fine cursor positioning (i.e., accurate placement of the cursor within the desired one pixel of the target.) The B-2 crewmembers had little confidence in the accuracy of their radar update designations and were concerned about the subsequent precision of the navigation and bombing solutions.

This problem was briefed at the 15 April 1993 Watch Item Review Board and upgraded to Service Report Status. Subsequently, the B-2 SPO became involved and asked AL/CFHI at WPAFB to investigate other possible cursor designs for this application.

As a result of these concerns, AL/CFHI was tasked to conduct a laboratory evaluation of the B-2 cursor and to recommend an alternative cursor design for application that would allow crewmembers to quickly and accurately designate aim points within one pixel. Specifically, AL/CFHI was asked to arrive at an optimum size and shape of the B-2 radar cursor.

## Approach

A review of published literature relevant to the radar cursor study was conducted. Of particular interest was research conducted using a cursor or position designator to perform a target designation task similar to that required by the B-2 Mission Commander. Because the cursor study focused on target designation accuracy and speed for a SAR imagery application, researchers were particularly interested in technical reports that focused on similar applications. Online computerized databases (i.e., Defense Technical Information Center (DTIC) Technical Report Bibliographic (TR) Database on CD-ROM and DTIC Work Unit Information System (WUIS)), containing bibliographic citations to over 650,000 technical reports, patent application, and conference papers covering more than 22 years, were searched using the following keywords:

- control dynamics
- cursor/radar cursor
- position designator
- control/display gain ratio
- isometric control
- concave force controller

The search for published work in the area of cursor size and shape for a SAR imagery application or a similar environment yielded very little relevant research. A number of reports were located that addressed related issues such as relevant factors when selecting input devices (joysticks, touch screen, trackball, etc.); display/control gain issues (i.e., the amount of movement which occurs on the display in response to a unit amount of movement of the control); and isotonic vs. isometric controls. However, because this effort was limited to identifying the optimum size and shape of the radar cursor, this related research was outside the scope of the current study.

A decision was made by AL/CFHI and the B-2 SPO to evaluate the effectiveness of the current cursor and two alternative cursors. The task upon which the evaluation was based consisted of a radar update procedure in which subjects identified and designated aim points using the current and two alternative cursors. The experimental approach included the use of the B-2 Computer-Assisted Procedures Trainer (CAPT) resident at AL/CFHI in order to conduct a laboratory evaluation in an interactive, semi-operational environment. The procedure was conducted using simulated SAR imagery containing representative cultural and terrain aim points displayed at the CAPT's Mission Commander's Position. A decision was made to evaluate the cursors on two criteria, including the speed with which a designation was made and the accuracy of designation. In addition to this performance data, subjective evaluations of the cursors and their effectiveness were collected from the subjects participating in the study.

## Cursor Selection And Description

Cursor 1 (i.e., the current cursor used on the B-2 radar display) and its dimensions are shown in Figure 1.1. This cursor is composed of cursor bars that are three pixels wide by ten pixels long, and has a center opening of seven by seven pixels. As mentioned above, Cursor 1 was described by B-2 aircrews as being too "fat" because the wide bars obscure vital visual information on and around the target. Crewmembers also commented that they often initially slew the cursor *away* from the desired designation point in order to clearly see the area of interest. The design of the alternative cursors was intended to eliminate these problems.

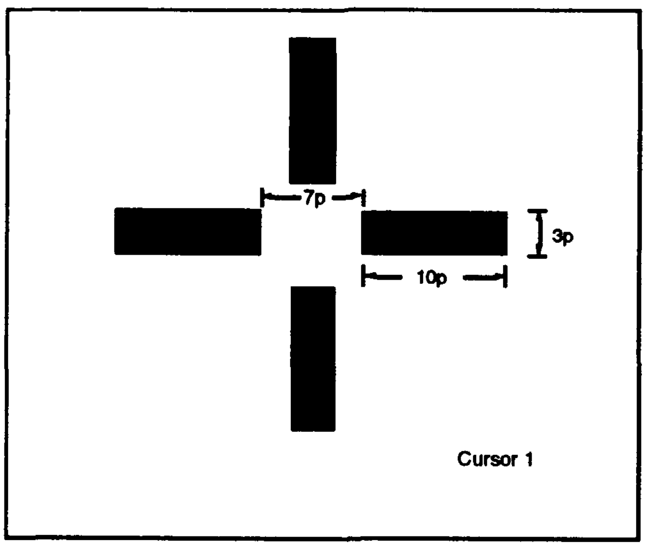
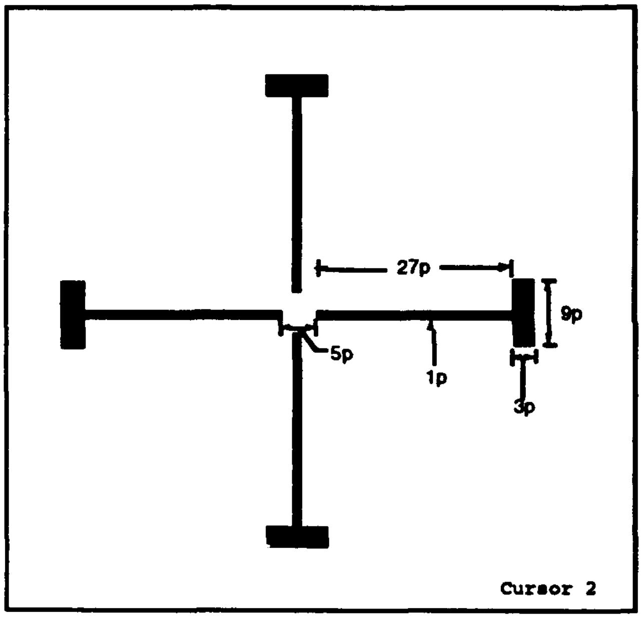
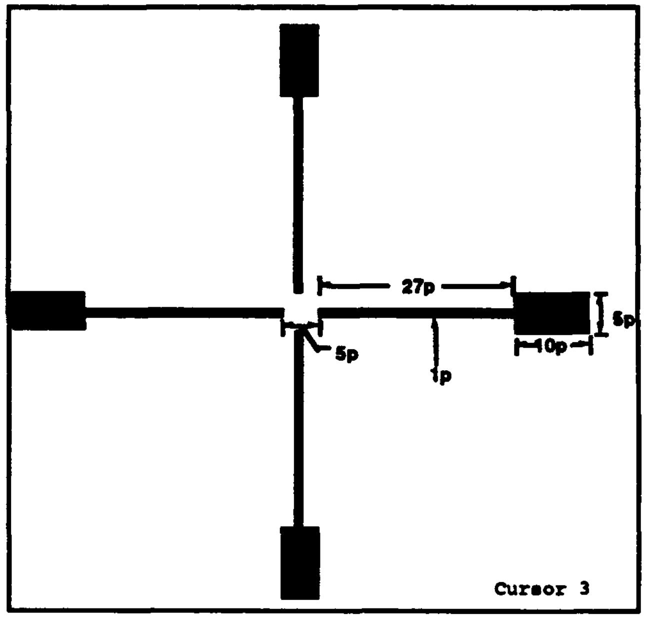



Figure 1.1. Cursor 1: Current B-2 Synthetic Aperture Radar Cursor.

The design of alternative cursors involved a subjective and iterative process. Very little previous research had been published in the area of radar cursor design in terms of size and shape. Therefore, the design process focused on addressing the specific concerns and observations of the B-2 crewmembers. These concerns centered around the width and length of the four cursor bars, the size of the center opening, and the overall visibility of the cursor. The first and most obvious alteration to the current cursor involved designing alternative cursor bars that were thinner and did not obscure as much of the area of interest on the SAR imagery. As depicted in Figure 1.2, both of the alternative cursors (i.e. Cursors 2 and 3) are composed of bars that are only one pixel wide.




Cursor 2




Cursor 3

Figure 1.2. Two Alternative Cursor Designs (Cursors 2 and 3).

Once the cursors were reduced in width (i.e., to one pixel wide), the problem of image obscuration was diminished. However, the thinness of the bars and the overall small physical size of the cursors made it much less conspicuous and very difficult to see when positioned on areas of the imagery that contained a high degree of background returns (i.e., high-clutter environments). To address this problem, each of the four cursor bars was extended in length from 10 pixels (Cursor 1) to 27 pixels (Cursors 2 and 3). In addition, terminators or end points were added to the outside end of each cursor bar. These provide visual referents to facilitate visual localization of the cursor

(especially in cluttered imagery). Additionally, terminators on reticle cursor designs facilitate vernier alignment processes and can lead to greater spatial localization accuracies. These serve as an aid in accomplishing accurate positioning of the cursor. The design of the Cursor 2 terminators, by virtue of being aligned perpendicular to their respective cursor bars, provides an additional diagonal vernier referent as well. To address the problem of the wide center opening in the current cursor, the opening of the alternative cursors was reduced from a width of seven pixels to five pixels, decreasing the center area by approximately 50%. This was intended to reduce the amount of visual interpolation required to estimate the exact center of the cursor (see Figure 1.2).

## SECTION II
## Method

This section addresses the experimental design and procedures used in the study.

### Subjects

A total of eighteen (18) subjects participated in the experiment. As depicted in Table 2.1, the subjects consisted primarily of current or previous USAF operators with radar and navigation experience in the B-2, B-1, and/or B-52 aircraft. Those subjects that had experience in either the B-1 or B-2 also had previous experience operating SAR.

Table 2.1. Subject Background and Experience.

| Aircraft Type | Position | Sensor | Experience Operating Crosshair |
|---|---|---|---|
| B-2 = 2<br>B-1 = 8<br>B-52 = 13<br>Other = 6 | OSO = 7<br>WSO = 2<br>RN = 8<br>NAV = 7<br>Pilot = 1<br>EWO = 3 | SAR = 9<br>EVS/FLIR = 14 | 17 |

### Apparatus

The study was conducted using the B-2 Computer-Assisted Procedures Trainer (CAPT) resident at AL/CFHI, and made use of the following five distinct hardware elements:

a. Silicon Graphics 4D-320 workstation (IRIS3) for image generation and cursor display.
b. Zenith Z-248 PC (linkage computer) for sampling of subject activity.
c. VT-220 terminal hooked to the SG as an operator console.
d. Top center MDU at the right seat of the CAPT for display of imagery to the subject.
e. Track handle (i.e., cursor controller) at the right seat of the CAPT.

The simulated SAR imagery was generated via the software in the SG which was under the control of the operator at the VT-220 console. This imagery was presented to the subject on a 1024x1024 pixel non-interlaced MDU display. This MDU had two times the vertical and horizontal resolution of the MDU currently used in the B-2 (512x512 pixels). Therefore, for the experiment, each 1024x1024 pixel was mapped to a block of four pixels to create the appearance of a 512x512 display and to emulate the aircraft for cursor positioning. Thus, the term "pixel" referred to in this study is equivalent to a pixel in the actual aircraft. Additional hardware and software were incorporated into the B-2 CEF baseline, allowing the linkage computer to accept subject inputs from the CAPT track handle (cursor movement commands) and from the MDU bezel buttons (image cycling commands). The hardware configuration is depicted in Figure 2.1.

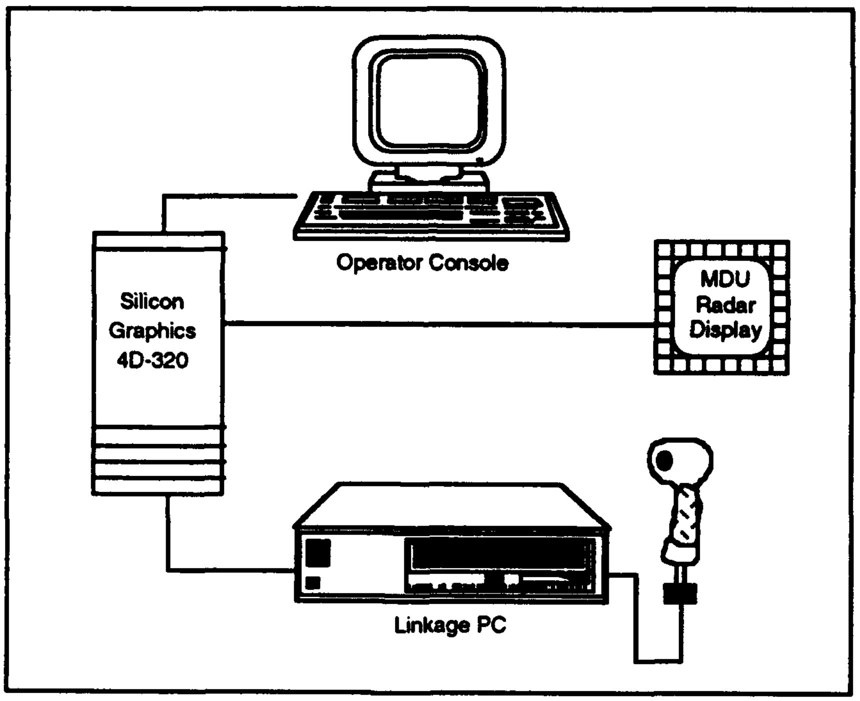



Figure 2.1. Cursor Study Hardware Configuration.

Stimuli

The stimuli used in the experiment consisted of simulated SAR imagery produced by a High-Resolution Ground Mapping Radar Simulator. This system uses an improved Digital Radar Landmass Simulator (DRLMS) database and applies United States Geological Survey (USGS) high-altitude photographic data as source imagery combined with a variety of low-cost, commercially-available hardware and software products to

create an image synthesization process capable of generating simulated high-resolution radar images. A total of 40 unique simulated SAR images were developed for use as stimuli in the experiment. Of the five patch sizes available for SAR presentation in the B-2, the second smallest patch size was used. The radar fix point (RFP) cards, which the subjects examined to identify the aim points, were generated using the USGS photo imagery. Each RFP card contained a verbal description of the target and a small circle drawn around the target in the photo. In the center of that circle, a single pixel was highlighted. This pixel was considered to be the golden pixel which the subjects were instructed to designate. The RFP cards and operational procedures were highly representative of those employed in the aircraft. An example of an RFP card is shown in Figure 2.2.


Figure 2.2. Radar Fix Point Card.

## Experimental Variables

The independent variable for the study was the type of cursor used for the task. These cursors have been described in detail above. The three cursor types were evaluated on two criteria: designation speed and designation accuracy, which are defined below.

- Designation Speed: The elapsed time between the initial appearance of the SAR image on the MDU and the time at which the subject designated a point on the image.

- Designation Accuracy: The distance (in pixels) between the golden pixel and the actual pixel designated (also called Designation Error). This distance was calculated using the following equation:

$$Error_d = \sqrt{(Error_x)^2 + (Error_y)^2}$$

where $Error_d$ is the overall designation error, $Error_x$ is the error in pixels on the x or horizontal axis, and $Error_y$ is the error on the y or vertical axis.

## Procedure

Prior to beginning the experimental trials, subjects were provided with written instructions regarding the procedure (see Appendix A, Instructions For Radar Cursor Study), and any questions they had were discussed. Ambient room lighting was set at 5 ft. candles to approximate representative nominal daytime light levels in the cockpit. Each subject was seated in the Mission Commander's (right hand) seat of the CAPT where he was made familiar with the MDU and the cursor controller. For each experimental trial, the subject followed the following procedures, which are consistent with those employed in actual mission scenarios.

- Studied the appropriate RFP card until sufficiently comfortable with the aim point, its location, and associated surroundings. (No time restriction).

- Depressed the "EXC" button located in the upper left corner of the center MDU. This action initiated the trial (a computerized timer began counting) and the SAR image appeared on the MDU with the cursor positioned in the center of the screen. The golden pixel was offset from the center of the screen by a distance that varied between 4 and 17 pixels on any given trial.

- Located the aim point that was circled on the RFP card on the displayed SAR image. Using the "SLEW" button on the cursor controller, positioned the cursor on the aim point, precisely over the golden pixel identified on the RFP card. Subjects were instructed to complete the designation task "as accurately and as quickly as possible."

- Once satisfied with the cursor placement, the subject depressed the trigger on the cursor controller to designate the aim point. The action ended the trial and caused the MDU to go blank until the next trial was initiated. The trial would automatically end if a designation was not made within 60 seconds.

Each of the 18 subjects performed a total of 150 trials, of which 30 were practice trials. As depicted in Table 2.2, the first 15 trials consisted of practice trials in which the subject performed five trials with each of the three cursors. The subject then performed three blocks of 45 trials. Within each block the subject used only one cursor. To minimize practice effects during the course of the experimental session, the order in which the blocks were presented was counterbalanced across the subjects. In addition, the first five trials of each block were considered practice trials in order to minimize practice effects as each new cursor was introduced. Thus, each subject performed 40 data collection trials for each cursor type, or a total of 120 data collection trials. This resulted in a total of 2160 designation performance measures collected.

Table 2.2. Data Collection Approach.

| Practice | Test | |
|---|---|---|
| 15 | | Warm up trials (3 cursor Types) |
| 5 | 40 | Block 1 |
| 5 | 40 | Block 2 |
| 5 | 40 | Block 3 |

Data Set: 18 Subjects
x 120 Trials

2160 Data Collection Trials

## Subjective Data Collection

Upon completing the experimental session, subjects participated in a debriefing session. During this interview session, a questionnaire was used and responses were audio recorded. Subjects were asked questions about their background and experience that might be relevant to performance data collected during the study. In addition, they were asked a number of questions regarding characteristics of the cursors, the overall technique or strategy they used for cursor positioning and designating aim points, the cursor controller mechanization (i.e., controlling the cursor position), and the realism of the part-task simulation. The debriefing questionnaire is contained in Appendix B and the detailed results to the debriefing sessions are contained in Appendix C.

## SECTION III
## Results

This section of the report presents the results of the analyses performed on the performance and subjective data from the part-task simulation.

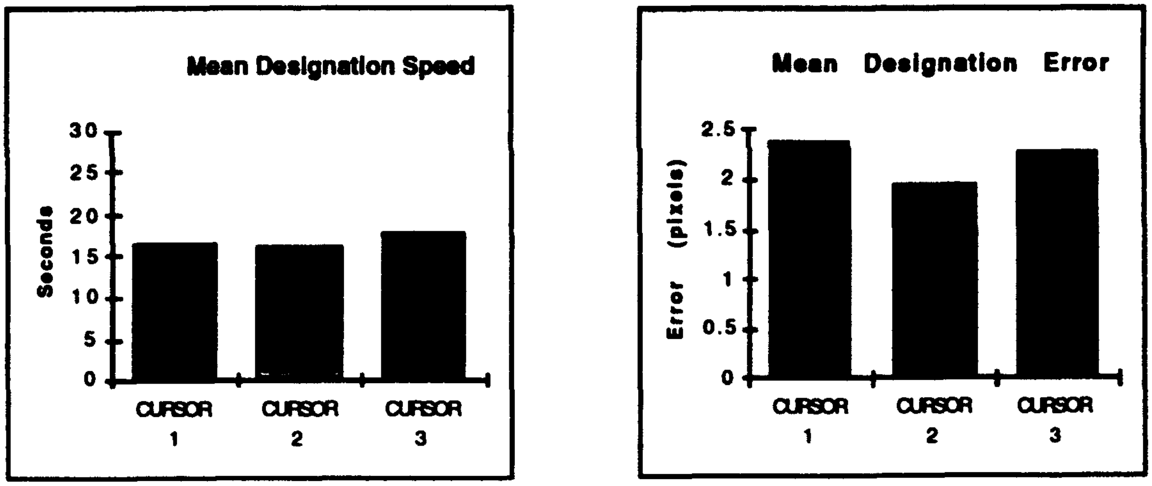
### Performance Results

As stated earlier, the dependent variables of interest included the speed and accuracy (degree of error) with which the subjects were able to designate the golden pixel across the three cursor types. However, additional data was collected that tracked the position of the cursor on the screen during the course of each trial. The goal of collecting the cursor position and movement data was to gain an insight into the type of designation strategies subjects used with each of the cursors. In addition, it provided a means of evaluating the adequacy of the cursor controller mechanization by indicating the number of directional reversals in cursor movement during a given trial. These reversals indicated the overshooting of the intended designation point.

Descriptive statistics for both designation speed and designation error are presented below in Table 3.1. These means are also graphed for each cursor in Figures 3.1 a and b.

Table 3.1. Descriptive Statistics for Designation Speed and Error.

| Cursor | Speed (sec) | | Error (pixels) | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. |
| Cursor 1 | 16.41 | 8.90 | 2.36 | 2.28 |
| Cursor 2 | 16.09 | 8.35 | 1.94 | 2.06 |
| Cursor 3 | 17.64 | 10.35 | 2.28 | 2.52 |




(a) (b)

Figure 3.1. Mean Designation Speed (a) and Designation Error (b) for Three Cursors.

As depicted in Figure 3.1a, designation speed was very similar across the three cursors. However, designation error (Figure 3.1b) appears to have been lower (higher accuracy) for Cursor 2 than for the other cursors. To test for significant differences among the speed and error means, two one-way Analyses of Variance (ANOVA's) were conducted. For the dependent variable Designation Speed, the ANOVA yielded an $F = 1.23$, ($df = 2,34$, $p. = .3042$), indicating that there was no significant difference between means for designation speed across the three cursors at alpha = .05. For the variable Designation Error, however, the ANOVA yielded a significant difference: $F = 13.16$, ($df = 3,34$, $p. = .0001$). A Tukey Studentized Range Test was then conducted to identify the significant differences among means. The Tukey test yielded a minimum significant difference value of .212 (df = 34, alpha = .05, MSE = 2.694). Examining the means for Designation Error in Table 3.1, it can be seen that the difference between Cursor 3 and Cursor 2 (.34) as well as the difference between Cursor 1 and Cursor 2 (.42), exceed the minimum significant difference of .212, indicating that Cursor 2 elicited significantly lower designation error (higher accuracy) than either Cursor 1 or Cursor 3, which were not statistically different from each other.

Designation Technique/Strategy

A number of subjects reported using different designation strategies for the different cursors. This is discussed in more detail below with regard to the subjective evaluations. In order to examine the difference in designation strategy, the cursor position data was examined. The mean cursor position, in terms of its distance from the

golden pixel, was calculated across all trials and plotted as a function of time for each of the three cursors. This plot is depicted in Figure 3.2.

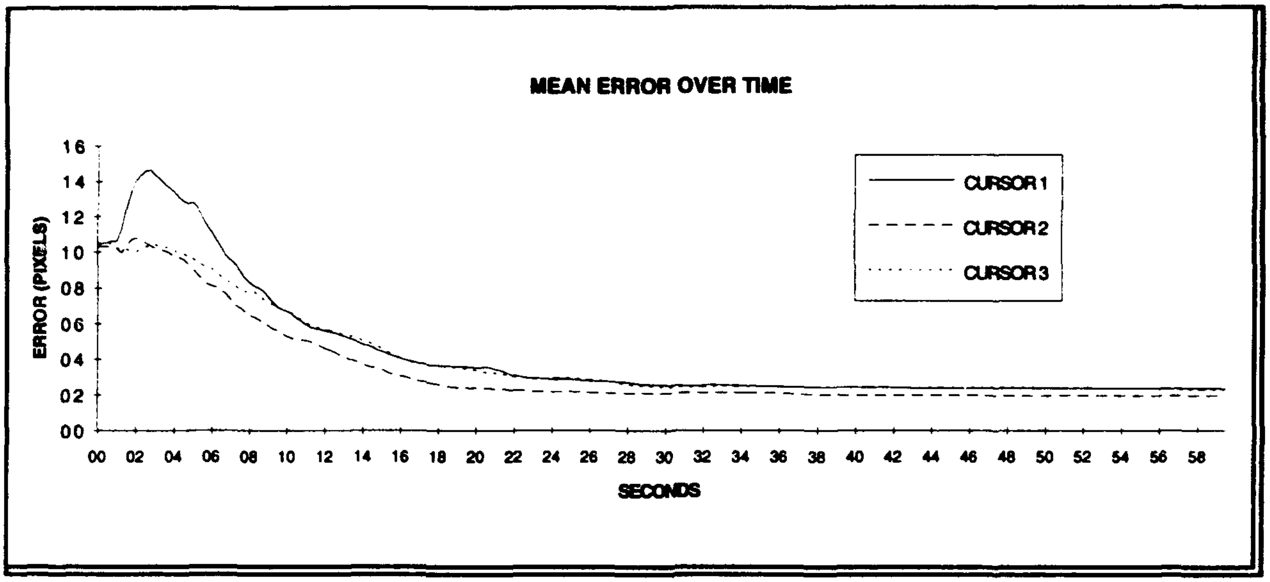



Figure. 3.2. Mean Designation Error over Time.

Figure 3.2 shows that for Cursor 1, subjects tended to slew the cursor *away* from the golden pixel at the onset of the trial before slewing toward the golden pixel to designate. For Cursors 2 and 3, however, subjects tended to slew immediately toward the golden pixel. This action is consistent with the subjects' comments regarding designation strategy discussed below.

Mechanization

Upon analyzing subjects' comments regarding the mechanization of the cursor controller (see Subjective Results), it became clear that subjects were dissatisfied with their ability to accomplish fine positioning of the cursor, regardless of which cursor was used. Subjects commented that when trying to position the cursor on the golden pixel, they often overshot the desired pixel repeatedly, and attributed this to their inability to easily move the cursor a distance of one pixel at a time. Figure 3.3 below illustrates this point, showing a random trial for a single subject. This figure shows the distance from the golden pixel in the **x** and **y** dimensions during the course of a single trial. On this trial, the subject, repeatedly maneuvered the cursor to the appropriate pixel on the display on both the **x** and the **y** dimensions. However, he was not able to stop the movement in time to keep the cursor on the desired pixel. This is demonstrated by the repeated

changes in both the horizontal (**x**) and vertical (**y**) directions and transgressions of the 0-error point.

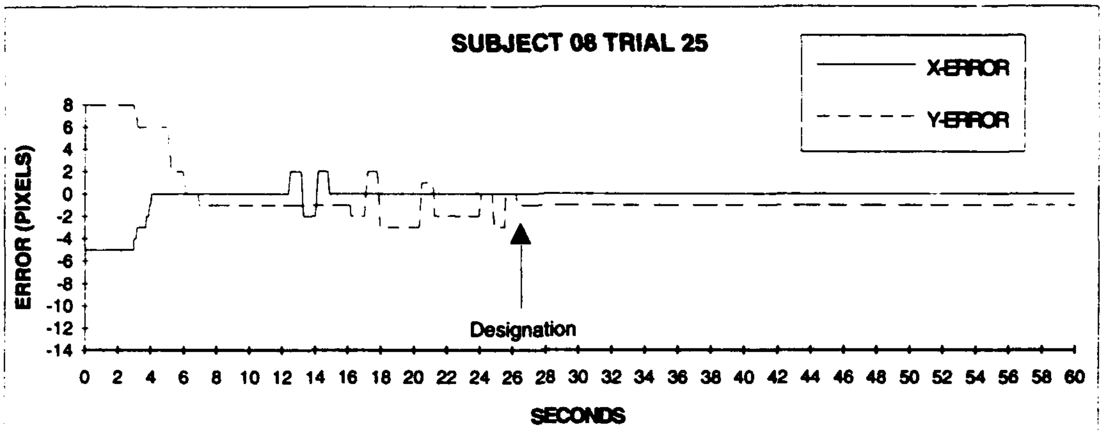



Figure 3.3. Designation Error Over Time for a Single Subject and a Single Trial.

In this particular example, the subject was using Cursor 3. However, this same pattern of difficulty with fine positioning could be seen with all three cursor types.

A closer examination of the cursor position data confirmed that subjects were consistently maneuvering the cursor past their desired designation point. The number of reversals in the direction of cursor movement on the **x** and **y** axes was counted for each trial and then averaged by cursor type across all trials. The mean number of reversals on each axis is listed by cursor type in Table 3.2.

Table 3.2. Mean Number of Reversals in Cursor Movement per Trial.

| | Mean Number of Reversals Per Trial | | |
|---|---|---|---|
| Cursor Type | x-axis | y-axis | Total |
| 1 | 2.53 | 2.30 | 4.83 |
| 2 | 2.32 | 2.14 | 4.46 |
| 3 | 2.66 | 2.44 | 5.10 |
| Combined | 2.50 | 2.29 | 4.80 |

The data in Table 3.2 indicate that on each trial, subjects were reversing the direction of the cursor movement an average of four to five times. This reversal in direction of cursor movement reflects the fact that subjects repeatedly overshot the desired pixel.

That is, they would move in the direction of the golden pixel, continue past it, and then reverse direction to move toward it again. This inability to control fine movements of the cursor position is discussed in more detail below.

## Performance Measures Summary

The following provides a summary of the results of the performance measures:

- Cursor 2 elicited significantly higher designation accuracy (mean error = 1.94 pixels) than the current cursor (Cursor 1, mean error = 2.36 pixels) or the second alternative cursor (Cursor 3, mean error = 2.28 pixels).

- Designation speed did not vary significantly across cursors, occurring approximately 17 seconds into a trial for all three cursors.

- When performing the radar update procedure with the current cursor (Cursor 1), subjects initially moved the cursor **away** from the intended designation point, before returning to the aim point and designating. With both alternative cursors, subjects tended to move directly toward the intended designation point.

- When moving the cursor toward the intended designation point, subjects overshot the intended point an average of 4.8 times per trial across all three cursors.

## Subjective Results

This section presents a discussion and summary of the responses obtained during the debriefing interview. The subjects' responses are organized into the following four categories based on the questionnaire: (1) Evaluation of the Cursor, (2) Description of Designation Technique, (3) Evaluation of the Cursor Mechanization, and (4) Evaluation of the Part-Task Simulation. Appendix B consists of the questionnaire used in the debriefing interview.

A summary of the quantitative and qualitative responses to each questionnaire item is contained in Appendix C. For each of the rating scales, the mean and standard deviation are presented. In addition, summaries of the comments are presented for each question.

## Evaluation of the Cursor

During the debriefing session, subjects were asked to separately rate Cursors 1, 2, and 3 on eight distinct dimensions or physical characteristics. A five point anchored rating scale (1 = very difficult; 5 = very easy) was used. The following figures graphically display the results of the rating analysis on the eight dimensions.

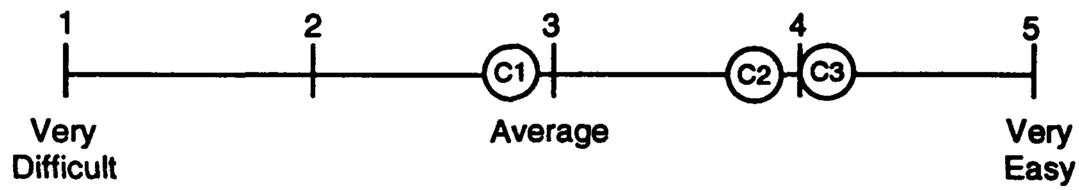



Figure 3.4. Visual Localization. Mean ratings for three cursor types on the dimension of "**Visually locating** or seeing the cursor." C1 = 2.78; C2 = 3.89; C3 = 4.06.

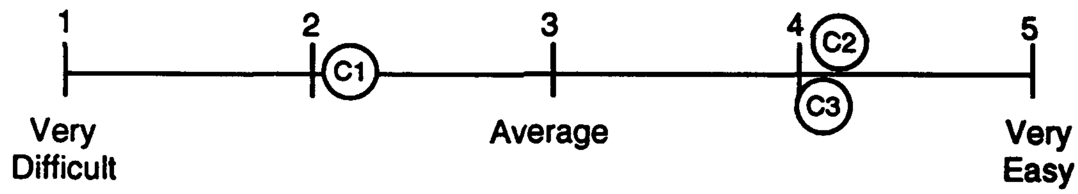



Figure 3.5. Visualization of Cursor Intersection. Mean ratings for three cursor types on the dimension of "**Accurately visualizing** the center of the cursor intersection." C1 = 2.28; C2 = 4.17; C3 = 4.11.

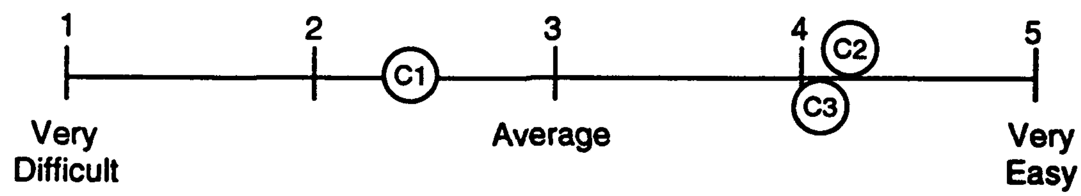



Figure 3.6. Cursor Positioning. Mean ratings for three cursor types on the dimension of "**Accurately positioning** the center of the cursor over the desired designation point." C1 = 2.44; C2 = 4.22; C3 = 4.11.

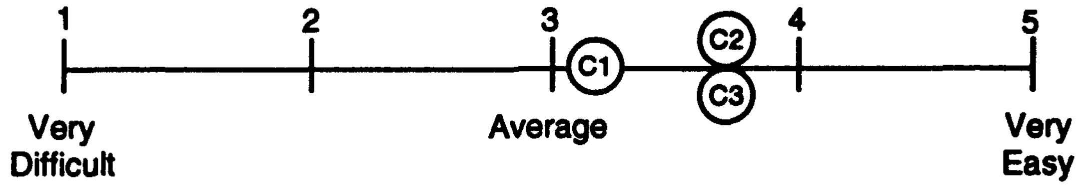



Figure 3.7. Cursor Positioning Speed. Mean rating for three cursor types on the dimension of "**Quickly positioning** the center of the cursor over the desired designation point." C1 = 3.11; C2 = 3.72; C3 = 3.72.

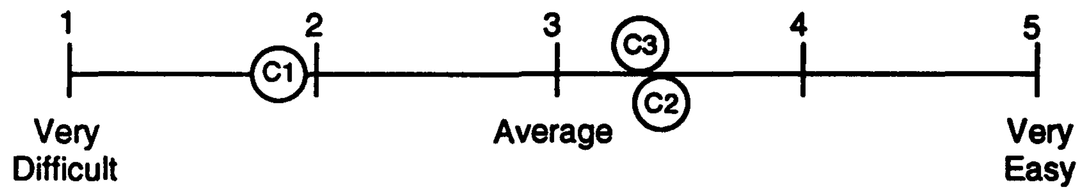



Figure 3.8. High-Clutter Environment. Mean rating for three cursor types on the dimension of "Designating aim points in a **high-clutter environment.**"
C1 = 1.83; C2 = 3.44; C3 = 3.39.

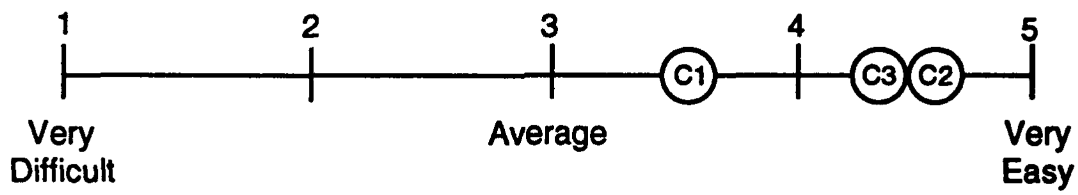



Figure 3.9. Uncluttered Environment. Mean rating for three cursor types on the dimension of "Designating aim points in an **uncluttered environment.**"
C1 = 3.61; C2 = 4.61; C3 = 4.44.

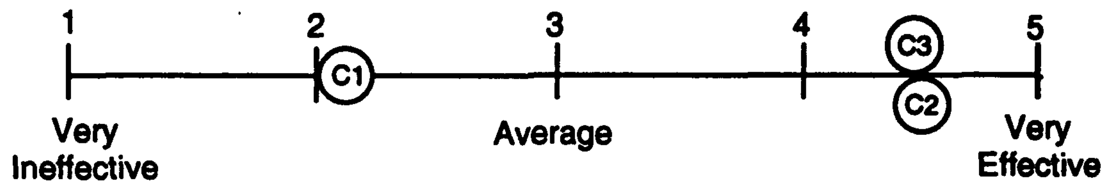



Figure 3.10. Cursor Effectiveness. Mean rating for three cursor types on the dimension of "**Overall effectiveness** of each cursor type for designating aim points."
C1 = 2.17; C2 = 4.56; C3 = 4.50.

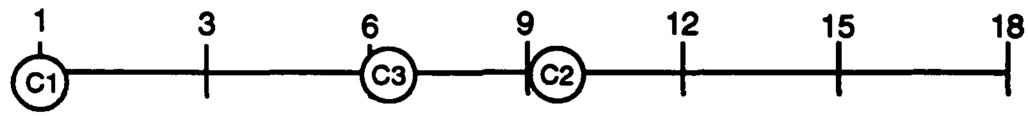



Figure 3.11. Cursor Performance. Number of respondents choosing each cursor on the dimension of "Cursor which provided **best overall performance.**"
C1 = 1; C2 = 10; C3 = 7.

As depicted in Figures 3.4 through 3.11, subjects consistently rated Cursors 2 and 3 more favorably than Cursor 1 in terms of level of difficulty and overall effectiveness for all eight dimensions. When asked to rate the three cursor types on the dimension of "**Visually locating** or seeing the cursor," subjects found Cursors 2 and 3 to be easier to locate due to the longer and narrower bars and the inclusion of terminators or end points. In contrast, they found that Cursor 1 often blended into the background when positioned in areas containing bright returns, thereby obscuring the area of interest. Mean ratings for "**Accurately visualizing** and **accurately positioning** the center of the cursor over the desired designation points" showed Cursors 2 and 3 to be widely preferred over Cursor 1. Subjects stated that Cursor 1 was more difficult to accurately visualize and accurately position due to the large center opening and the width of the cursor bars. When asked to rate the three cursor types on the dimension of "**Quickly positioning** the center of the cursor over the desired designation point," subjects expressed difficulty evaluating all cursors on speed due to the problems they consistently experienced with the mechanization (i.e., controlling the controller position). They did state however, that Cursor 1 required an extra step of moving *away* from the golden pixel in order to see the area of interest. Subjective comments demonstrated that Cursors 2 and 3 were preferred when designating aim points in a **high-clutter**

**environment.** Subjects attributed this to the fact that Cursor 1 obscured areas of interest, particularly when the SAR imagery contained a number of bright returns. In contrast, they found that the length of the bars and the end points on Cursors 2 and 3 allowed them to line up past bright returns.

As depicted in Figures 3.10 and 3.11, Cursors 2 and 3 were found to be superior to Cursor 1 in terms of **overall effectiveness and performance**. Subjects found Cursor 1 to be "somewhat ineffective" due to the width of the bars, the length of the bars, large center opening, and overall size. Those subjects who favored Cursor 2 stated that they preferred the overall size, narrow bars, and perpendicular end points. Subjects who found Cursor 3 to be superior cited the versatility of the design; wide end points to acquire the cursor and for performing gross positioning, and narrow, internal bars for fine positioning and final designation.

Finally, subjects were asked to suggest improvements to the cursor they found to be the best overall performer. Although the majority of the subjects did not feel that improvements to Cursors 2 and 3 were required, a few subjects who selected Cursor 2 recommended that the overall size could be further increased (i.e., the bars lengthened); those subjects who selected Cursor 3 recommended the inclusion of a blinking or flashing capability to maximize the contrast between the cursor and the background.

Description of Designation Technique/Strategy

During the debriefing session, subjects were asked to describe the overall technique or strategy they used for cursor positioning and designating aim points. Similarities and differences for each of the cursors were recorded. As described earlier in this report, a number of subjects reported using a different strategy for Cursor 1 than Cursor 2 and Cursor 3. For Cursor 1, subjects tended to slew the cursor *away* from the golden pixel at the onset of the trial in order to uncover important information in the area of interest. In contrast, subjects were able to slew immediately toward the golden pixel when using Cursors 2 and 3. These comments are consistent with the performance data depicted in Figure 3.2 (Mean Designation Error over Time).

Subjects stated that they were able to accomplish fine positioning more easily with Cursors 2 and 3. They attributed this to another strategy they reported to be effective

which involved using the longer and thinner bars of Cursors 2 and 3 to line up on the golden pixel one axis at a time. Because of the larger opening and shorter, wider bars on Cursor 1, subjects found they were unable to use this same strategy with the current cursor.

## Evaluation of the Cursor Mechanization

During the debriefing session, subjects were asked to rate the difficulty of controlling the cursor position in terms of designation speed and accuracy. A five point anchored rating scale (1 = very difficult; 5 = very easy) was used. Results yielded a mean rating on the dimension of mechanization of 1.72, indicating that subjects found it difficult to control the cursor position. Regardless of cursor type, subjects consistently expressed dissatisfaction with their ability to control the cursor, particularly in the area of fine positioning. As stated previously, subjects commented that when trying to position the cursor on the golden pixel, they often overshot the desired pixel repeatedly, and attributed this to their inability to easily move the cursor a distance of one pixel at a time. As depicted in Figure 3.3 (Designation Error over Time for a Single Subject and a Single Trial) and Table 3.2 (Mean Number of Reversals in Cursor Movement per Trial), the performance data supported these subjective comments reported during the debriefing. Suggestions for improvement included (1) readjusting the slew rate to decrease overshooting and thereby improving fine positioning accuracy, and (2) investigating the use of a dual-rate (i.e., fast and slow) mechanization for gross and fine positioning.

A number of subjects objected to the cursor controller itself. They stated that too much pressure or force was required to move the cursor. In addition, subjects had difficulty locating the "sensitive area" on the controller. Suggestions for improvement in this area included: (1) decreasing the deadband, (2) greater movement of the controller in order to provide feedback, (3) proportional movement for force applied, and (4) possibly using a thumbwheel or trackball to provide greater back and forth movement.

In conclusion, many subjects found the current mechanization to be the source of greatest concern when accomplishing the radar update procedure. They stated that although they knew the location of the golden pixel, many times they were unable to position the cursor over the desired designation point due to the mechanization. They objected to having to employ a bumping strategy (i.e., tapping the controller in an

attempt to move the cursor one pixel at a time). All subjects felt that if the mechanization was improved, radar update accuracy would also greatly improve.

Evaluation of the Part-Task Simulation

In the final section of the debriefing questionnaire, subjects were asked to evaluate the realism of the part-task simulation. Specifically, subjective comments were recorded in the areas of simulated SAR imagery quality, the procedure used to accomplish the radar updates, mechanization of the cursor, and the quality of the RFP cards. As depicted in Table 3.3, subjective evaluations of the simulation indicated a high degree of fidelity on the above mentioned parameters.

Table 3.3. B-2 Cursor Study Debrief Results.

| QUESTION | NUMBER OF RESPONDENTS | MAXIMUM RATING POSSIBLE | MEAN | STANDARD DEVIATION |
|---|---|---|---|---|
| Rate realism of simulated SAR imagery presented during demonstration. | 17 | 3.00 | 2.67 | .61 |
| Aim point types typical of those you experience in your operational units? | 17 | Yes/No | 100% = Yes | -------- |
| Rate preset CONTRAST and BRIGHTNESS levels in terms of desirability. | 18 | 3.00 | 2.44 | .62 |
| Rate effectiveness of demonstration in simulating the radar update procedure | 16 | 5.00 | 4.44 | 1.03 |
| Rate effectiveness of demonstration in simulating the mechanization of the cursor. | 8 | 5.00 | 4.5 | 1.19 |
| Rate realism of RFP cards. | 15 | 3.00 | 2.60 | .51 |

In terms of realism of the simulated SAR imagery, subjects rated the imagery as being realistic (mean rating = 2.67 out of maximum rating of 3). When asked what SAR effects/characteristics would you change, three subjects suggested improvement in the area of shadowing. The aim points selected for the study were found to be typical of those seen in actual missions and subjects found the radar procedure to be very realistic in terms of what is performed in an operational environment (mean rating = 4.44 out of maximum rating of 5). Of particular interest was the mean rating on the effectiveness of the mechanization of the cursor. Although only eight of the subjects felt

they had sufficient experience to rate this dimension, those eight subjects found the mechanization to be very effective. That is, they found the study to have effectively simulated the current mechanization of the B-2.

## SECTION IV
## Discussion and Recommendations

### Discussion

Subjective evaluations of the current part-task simulation effort indicate that the study approach exhibited a high degree of fidelity with operational environment (i.e., SAR imagery quality, procedure used to accomplish the radar updates, mechanization of cursor, and quality of the RFP cards.) In addition, the CEF B-2 crewmembers who participated as advisors and subjects rated the hardware and software implementations as being highly representative of those in the B-2 aircraft. Thus, it is assumed that the results of the experimentation, in terms of relative effectiveness of the three cursors evaluated, can be generalized to the operational environment.

Both the performance and subjective results clearly indicate that the radar cursor currently being used in the B-2 could be modified to elicit more accurate designation and a higher degree of user acceptance. Crewmember complaints, which served as the impetus for conducting this study, were validated during the course of the experimentation. That is, subjects in the study demonstrated difficulty with the current cursor in terms of: (1) accurately placing the cursor with the precision of one pixel, (2) seeing relevant target information that was obscured by the cursor, (3) determining the exact center of the cursor, (4) locating the cursor in a high-clutter environment, and (5) controlling fine positioning of the cursor.

Perhaps the most vital aspect of performance in an aim point designation task is the accuracy with which the operator can designate the desired pixel. Error in this process is manifested in terms of imprecise radar updates and reduced accuracy of both the navigation and bombing solutions. Some degree of the designation error observed with the current cursor was thought to be due to the wide and short cursor bars (3 pixels wide by ten pixels long) and the rather large cursor opening (7 x 7 pixels). Subjective comments verified that subjects felt both these areas were a problem in terms of accuracy. Subjects rated the current cursor (Cursor 1) "somewhat ineffective" due to the width of the bars, the length of the bars, large center opening, and overall size. They preferred Cursors 2 and 3 because of the overall larger size, narrower bars, smaller center opening, and inclusion of end points. Performance results did in fact show that Cursors 2 and 3, with thinner and longer bars and smaller openings led to

lower mean designation error than Cursor 1. As stated previously, Cursor 2 elicited significantly higher designation accuracy (mean error = 1.94 pixels) than the current cursor (Cursor 1, mean error = 2.36 pixels) or the second alternative cursor (Cursor 3, mean error = 2.28). However, the difference in designation error was only statistically significant between Cursor 2 and Cursors 1 and 3. That is, Cursor 2 elicited significantly lower error than both Cursor 1 and 3. The improved performance of Cursor 3 over Cursor 1 was not statistically significant. This fact indicates that the above mentioned modifications (i.e., overall larger size, narrow bars, smaller center opening, and end points) may not have been the only factors affecting designation accuracy.

Extension of the length of the cursor bars (Cursors 2 and 3) elicited a higher degree of user acceptance in terms of the subjects' ability to locate the cursor on the screen. Subjective comments indicate that the longer (although narrower) bars of Cursors 2 and 3 made the cursor easier to locate when the SAR display first appeared. This effect was described by subjects to be exaggerated when the cursor appeared in an area of high returns. The resulting effect on mission performance of an inability to initially locate the cursor would seem to be a delay in designation time. However, a statistically significant difference in designation time across cursors was not observed. Although subjects expressed that, at times, they had difficulty locating Cursor 1 on the display screen, performance data indicated that this did not affect the overall time it took them to designate.

Cursors 2 and 3 were widely preferred over Cursor 1 in terms of overall performance. Of the subjects who preferred Cursor 3 over the others, many indicated that they preferred the longer terminator bars because they facilitated the act of locating the cursor as the display first appeared. As discussed above, this had no significant impact on designation time. However, those subjects who felt that Cursor 2 offered the best performance attributed this to the fact that the perpendicular terminators on Cursor 2 aided not only in their locating the cursor, but also in their accurate alignment of the cursor and subsequent designation. That is, the perpendicular terminators may provide better vernier alignment cues, enabling subjects to more easily align the cursor over the intended designation point. These comments, coupled with the performance results, suggest that the increased designation accuracy elicited by Cursor 2 could be attributed to both the smaller cursor opening and the perpendicular terminators.

Problems associated with obscuration of the imagery and subjects' inability to easily locate the cursor were evaluated for the current cursor and for both alternative cursors. Although not all subjects found obscuration to be a problem with Cursor 1, many subjects, when explaining their strategy of initially moving the cursor away from the designation point, commented that they found its bars to be too wide (three pixels). With Cursors 2 and 3, subjects did not find it necessary to move the cursor away from the target before designating (see Figure 3.2). Discussions with the subjects revealed that this was due to the fact that Cursors 2 and 3, with bars of only one pixel in width, did not tend to obscure vital visual information in the imagery.

Regardless of the physical characteristics of the current cursor and the two alternative cursors tested, subjects consistently expressed dissatisfaction with their ability to control the cursor, particularly in the area of fine positioning. Subjects commented that when trying to position the cursor on the golden pixel, they often overshot the desired pixel repeatedly, and attributed this to their inability to easily move the cursor a distance of one pixel at a time. Suggestions for improvement included both hardware and software changes (i.e., decreasing deadband, greater movement of the controller in order to provide increased feedback, readjusting slew rate to improve fine positioning). In general, subjects found the current mechanization to be the source of greatest concern when accomplishing the radar update procedure and felt that if the mechanization was improved, radar update accuracy would also greatly improve.

## Recommendations

Based on the performance results and subjective comments resulting from this test, it is suggested that Cursor 2 would yield an improvement over the current cursor in terms of a higher degree of designation accuracy as well as a higher degree of user acceptance. However, the increase in designation accuracy (from a mean error of 2.36 pixels with the current cursor to an mean error of 1.94 pixels with Cursor 2) does not meet the specified requirement of a mean designation error of one pixel or less.

Based on the overwhelming number of negative responses from subjects and B-2 crewmembers regarding the cursor controller mechanization, it is apparent that the inability to finely position the cursor may be equally, if not more, responsible for the error in aim point designation than the physical characteristics of the cursor. As a result of these subjective evaluations, it is recommended that the focus of any future

investigation of designation accuracy be directed toward optimizing the control mechanization of the cursor. An increased ability to make fine cursor movements, coupled with the improved physical design of the cursor, may lead to accuracy achieving the criterion of a single pixel.

## GLOSSARY OF TERMS

Cursor. The symbol displayed on the multipurpose display unit (MDU) that moves as the radar operator moves the slew button on the cursor controller. In this experiment, the cursor was used to designate aim points.

Dependent Variable. Some well-defined aspect of behavior (a response) that is measured in a study. The assumed value of the dependent variable is hypothesized to be dependent upon the value assumed by the independent variable and thus is expected to systematically change in response to relative changes in the independent variable. The dependent variable reflects any effects associated with the manipulation of the independent variable. In the current study, the dependent variables were *designation speed* and *designation error.*

Experimental Design. A specific plan used to systematically vary independent variables and note consequent changes in dependent variables.

Golden Pixel. The specific pixel on the RFP card and corresponding SAR image that subjects were instructed to designate.

Independent Variable. An aspect of the testing environment that is empirically investigated for the purpose of determining whether or not it influences the experimental outcome. Test variables or stimuli deliberately varied or controlled within the experiment to determine their effects on the dependent variables. In the current study, the independent variable was *cursor type.*

Trial. A discrete data collection event consisting of a single set of independent and dependent variables.

# APPENDIX A

## Instructions for Radar Cursor Study

## INTRODUCTION TO B-2 RADAR CURSOR DEMONSTRATION

You are invited to participate in a simulator-based demonstration that involves performing radar updates using simulated synthetic aperture radar (SAR) imagery. As you know, the purpose of performing these updates is to ensure the accuracy of the navigation and bombing solutions. The objectives of this study are:

- To demonstrate the functionality of the three radar cursors being tested.
- To evaluate the realism of the computer generated SAR imagery.
- To assess the adequacy of the man-machine interface used to support this task.

The demonstration will be conducted using the B-2 Computer Assisted Procedures Trainer (CAPT) resident at Armstrong Laboratory (AL/CFHI). This simulator, typically used for stand-alone B-2 procedures training, has been modified to allow AL scientists to evaluate B-2 controls and displays in an interactive environment. Do not be concerned if you are not familiar with the B-2 CAPT, as an in-depth knowledge will not be required. You will be well trained on all procedures necessary to participate in the study.

In order to allow adequate time for training, participation in the demonstration, and debriefing, we are requesting one half day of your time (either 0800 to 1200 or 1300 to 1700) to be spent in our facility. A schedule for the half day session will be as follows:

| Time | | Activity |
|---|---|---|
| AM | PM | |
| 0800-0830 | 1300-1330 | Orientation Briefing |
| 0830-0845 | 1330-1345 | Practice Session |
| 0845-0930 | 1345-1430 | Demonstration Block 1 |
| 0930-0945 | 1430-1445 | Break |
| 0945-1115 | 1445-1615 | Demonstration Blocks 2 & 3 |
| 1115-1200 | 1615-1700 | Debriefing |

The following is a brief description of the demonstration, the specific procedures that you will be following, and the materials or tools you will be using.

## DEMONSTRATION DESCRIPTION

During the demonstration, you will be presented with a simulated SAR imagery on the mission commander's center multipurpose display unit (MDU). All imagery will be presented NORTH UP and contain representative aim points typical of those used in an operational bomber unit (e.g., tanks, bridges, buildings, towers, etc.). Assume that the offensive avionics are operating normally and that a nominal buffer value exists. For each image presented, you will be asked to identify and designate an aim point as depicted on the Radar Fix Point (RFP) Graphic Card provided. Once the aim point is designated, the trial will end. It is important that you designate aim points for each of the trials as accurately as possible. In addition, designation should occur within a time frame that is consistent with an operational setting. Please note that the CONTRAST and BRIGHTNESS controls have been preset and that you will be unable to adjust their levels.

## DEMONSTRATION PROCEDURES AND TOOLS

The following describes the sequence of events for each trial, the displays you will see, the controls you will use to make your inputs, and the materials that will be provided.

1. Radar Fix Point (RFP) Graphic Cards. RFP cards have been developed to support each simulated SAR image for each trial. Contained on each RFP card is a photographic image of the desired aim point and the surrounding area. The orientation of the RFP card will always be presented NORTH UP. The aim point contained on each photograph will be circled to indicate the target you are to designate for that particular trial. Your job will be to study the RFP card for a short length of time prior to the beginning of a trial. The time at which a trial begins is under your control, thereby allowing you to study the card as long as you would like. RFP cards are labeled in the bottom left corner, indicating its associated block and trial number. For example, Block 1, image (i.e., trial) 30 would be designated as "B1-30."

2. Trial Procedure. The procedure you will use for designating aim points is as follows:

a. Locate the correct RFP card for the upcoming trial. Study the RFP card until you are sufficiently comfortable with the aim point, its location, and associated surroundings.

b. Depress the "EXC" button from coherent map display. This button is located in the upper left corner of the center MDU. This action initiates the trial and will cause the simulated SAR image to be displayed.

c. Once the SAR image is displayed, note that the image you are seeing on the MDU is the same image that is depicted on the RFP card. The crosshair or cursor is displayed in the center of the display.

d. Locate the aim point that was circled on the RFP card on the displayed SAR image. Using the SLEW button on the Cursor Controller, position the cursor on the aim point, precisely over the "golden pixel" identified on the RFP card. Remember accuracy is important, as these updates become part of the navigation and bombing solution on a real mission.

e. When you are satisfied with your aiming, depress the trigger on the Cursor Controller to designate the aim point. The action ends the trial and causes the MDU to be blanked until you initiate the next trial.

* Please complete the location and designation procedure as **accurately** and as **quickly** as possible.

This procedure will be repeated for a total of 135 images or trials. These trials will be organized into three groups or blocks of 45 images each. Each block will present a different radar cursor for you to use. The three cursors will vary in size and style. Block 1 will contain 45 images or trials using one type of cursor; Block 2 will contain 45 images using another type of cursor; and finally Block 3 will contain 45 images using still a different cursor.

3. Practice Session. As stated previously, you will participate in a practice session prior to the beginning of the demonstration. Using the procedure described above, you will

be given time to practice designating aim points using the three radar cursors being tested. This session will last approximately fifteen minutes and may be repeated until both you and the experimenter feel that you are comfortable with the procedure.

## DEBRIEFING INTERVIEW

At the completion of the demonstration, you will be asked to participate in a debriefing session. You will be asked questions about your background and experience that may be helpful to us in interpreting the performance data we collect during the demonstration. We will also be asking you questions about the functionality of the three radar cursors that were used. Finally, we will be asking you to evaluate the demonstration to include the realism of the imagery, the procedure used to accomplish the updates, and the operation of the Cursor Controller.

# APPENDIX B

## B-2 Radar Cursor Study Questionnaire

# B-2 RADAR CURSOR STUDY QUESTIONNAIRE

## SECTION 1: BIOGRAPHICAL DATA

The following section contains questions regarding your background and previous experience that might be relevant to the B-2 radar cursor demonstration. The information that you provide in this section may be helpful to us in interpreting the data we collect during the demonstration.

### A. Personal Data

| | |
|---|---|
| Name: | Rank: |
| Organization: | Phone: |

### B. Experience

1. List aircraft in which you are **currently qualified**, your crew position, and number of hours.

| AIRCRAFT | POSITION | TOTAL HOURS |
|---|---|---|
| 1. | | |
| 2. | | |

2. List additional aircraft in which you have been **qualified in the past**, your crew position, and number of hours.

| AIRCRAFT | POSITION | TOTAL HOURS |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |

3. Which of the following sensors have you operated and how many hours do you have with each type?

| SENSOR | AIRCRAFT | HOURS |
|---|---|---|
| EVS/FLIR | | |
| SAR | | |
| Other | | |

4. Describe your experience operating a crosshair using a cursor controller (ex. trackball, trackhandle) to include flight environment (high/low altitude) and hours.

______________________________________________

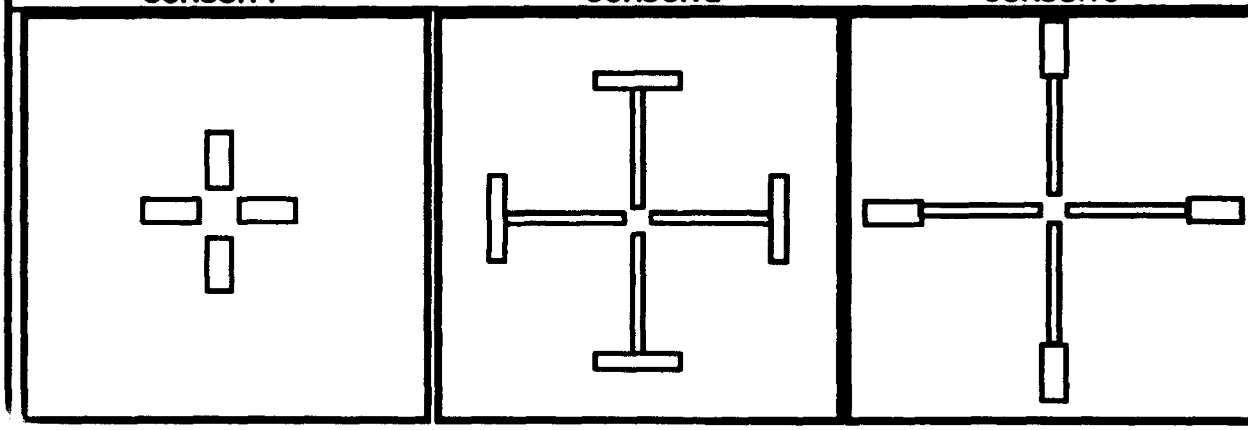
______________________________________________

______________________________________________

**SECTION 2: EVALUATION OF THE CURSOR**

**The following section contains questions regarding the three cursors tested, the technique you used to designate aim points, and the mechanization of the cursors.**

CURSOR 1 CURSOR 2 CURSOR 3



## A. Cursor Type

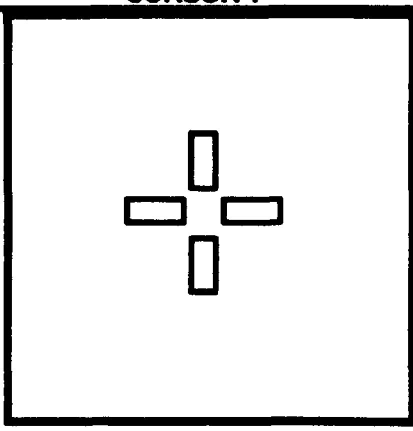
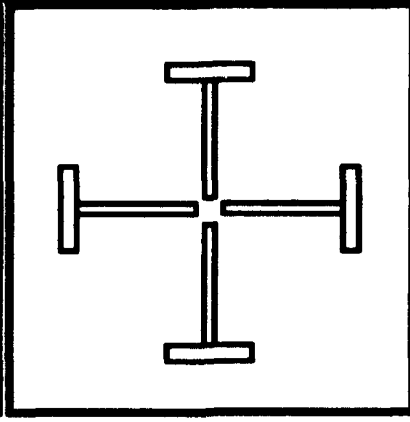
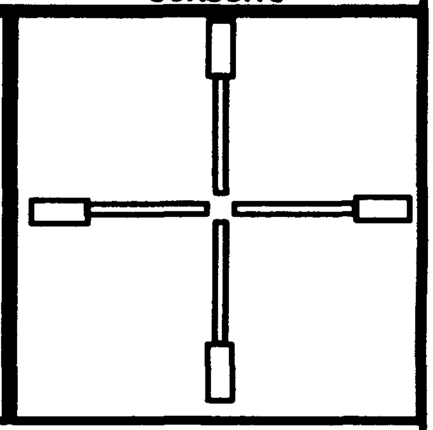
The following questions pertain to the characteristics of the cursors themselves. For each of the following categories, please rate each of the three cursors on a scale of 1 to 5.

How would you rate the level of difficulty for performing the following activities.

1. In general, **visually locating** or seeing the cursor.

| Cursor 1 | Cursor 2 | Cursor 3 |
|---|---|---|
| ☐ 1. Very difficult | ☐ 1. Very difficult | ☐ 1. Very difficult |
| ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult |
| ☐ 3. Average | ☐ 3. Average | ☐ 3. Average |
| ☐ 4. Somewhat easy | ☐ 4. Somewhat easy | ☐ 4. Somewhat easy |
| ☐ 5. Very easy | ☐ 5. Very easy | ☐ 5. Very easy |

Comments: ______________________________

| CURSOR 1 | CURSOR 2 | CURSOR 3 |
|---|---|---|
|  |  |  |

2. **Accurately visualizing** the center of the cursor intersection.

| Cursor 1 | Cursor 2 | Cursor 3 |
|---|---|---|
| ☐ 1. Very difficult | ☐ 1. Very difficult | ☐ 1. Very difficult |
| ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult |
| ☐ 3. Average | ☐ 3. Average | ☐ 3. Average |
| ☐ 4. Somewhat easy | ☐ 4. Somewhat easy | ☐ 4. Somewhat easy |
| ☐ 5. Very easy | ☐ 5. Very easy | ☐ 5. Very easy |

Comments: ______________________________________________

______________________________________________

______________________________________________

3. **Accurately positioning** the center of the cursor over the desired designation point.

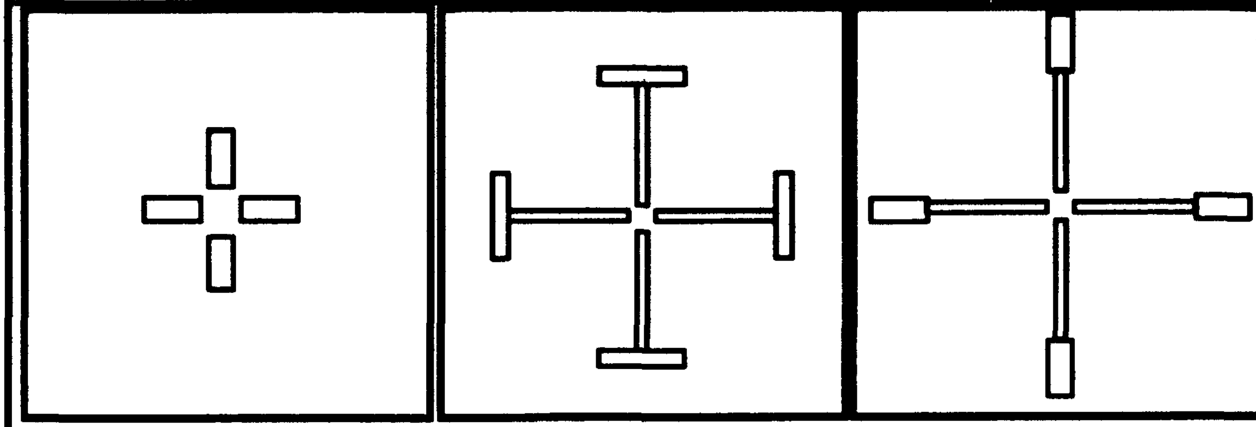
| Cursor 1 | Cursor 2 | Cursor 3 |
|---|---|---|
| ☐ 1. Very difficult | ☐ 1. Very difficult | ☐ 1. Very difficult |
| ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult |
| ☐ 3. Average | ☐ 3. Average | ☐ 3. Average |
| ☐ 4. Somewhat easy | ☐ 4. Somewhat easy | ☐ 4. Somewhat easy |
| ☐ 5. Very easy | ☐ 5. Very easy | ☐ 5. Very easy |

Comments: ______________________________________________

______________________________________________

______________________________________________

| CURSOR 1 | CURSOR 2 | CURSOR 3 |
|---|---|---|



4. **Quickly positioning** the center of the cursor over the desired designation point.

| Cursor 1 | Cursor 2 | Cursor 3 |
|---|---|---|
| ☐ 1. Very difficult | ☐ 1. Very difficult | ☐ 1. Very difficult |
| ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult |
| ☐ 3. Average | ☐ 3. Average | ☐ 3. Average |
| ☐ 4. Somewhat easy | ☐ 4. Somewhat easy | ☐ 4. Somewhat easy |
| ☐ 5. Very easy | ☐ 5. Very easy | ☐ 5. Very easy |

Comments: ______________________________________________

______________________________________________

______________________________________________

5. Designating aim points in a **high-clutter environment.**

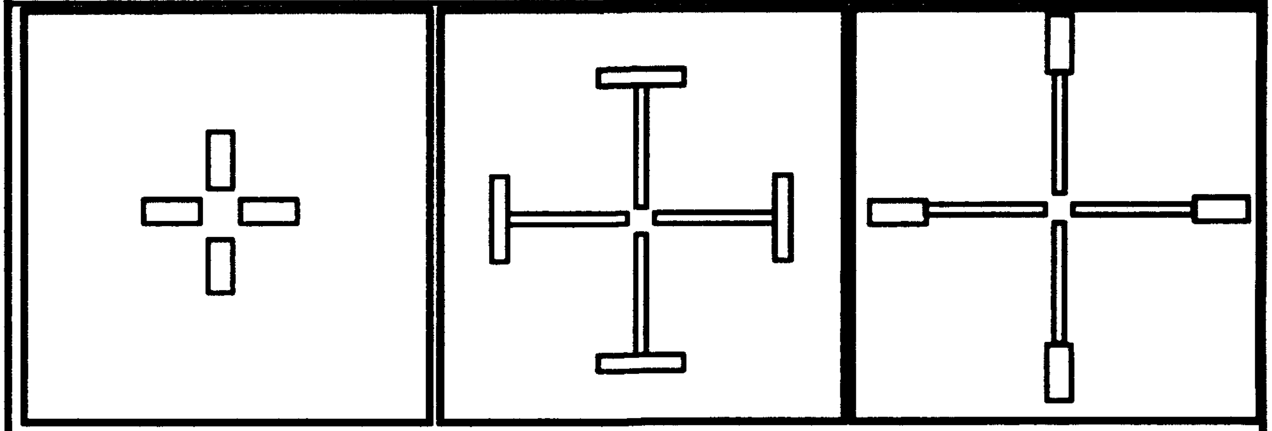
| Cursor 1 | Cursor 2 | Cursor 3 |
|---|---|---|
| ☐ 1. Very difficult | ☐ 1. Very difficult | ☐ 1. Very difficult |
| ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult |
| ☐ 3. Average | ☐ 3. Average | ☐ 3. Average |
| ☐ 4. Somewhat easy | ☐ 4. Somewhat easy | ☐ 4. Somewhat easy |
| ☐ 5. Very easy | ☐ 5. Very easy | ☐ 5. Very easy |

Comments: ______________________________________________

______________________________________________

______________________________________________

| CURSOR 1 | CURSOR 2 | CURSOR 3 |
|---|---|---|



6. Designating aim points in an **uncluttered environment**.

| Cursor 1 | Cursor 2 | Cursor 3 |
|---|---|---|
| ☐ 1. Very difficult | ☐ 1. Very difficult | ☐ 1. Very difficult |
| ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult | ☐ 2. Somewhat difficult |
| ☐ 3. Average | ☐ 3. Average | ☐ 3. Average |
| ☐ 4. Somewhat easy | ☐ 4. Somewhat easy | ☐ 4. Somewhat easy |
| ☐ 5. Very easy | ☐ 5. Very easy | ☐ 5. Very easy |

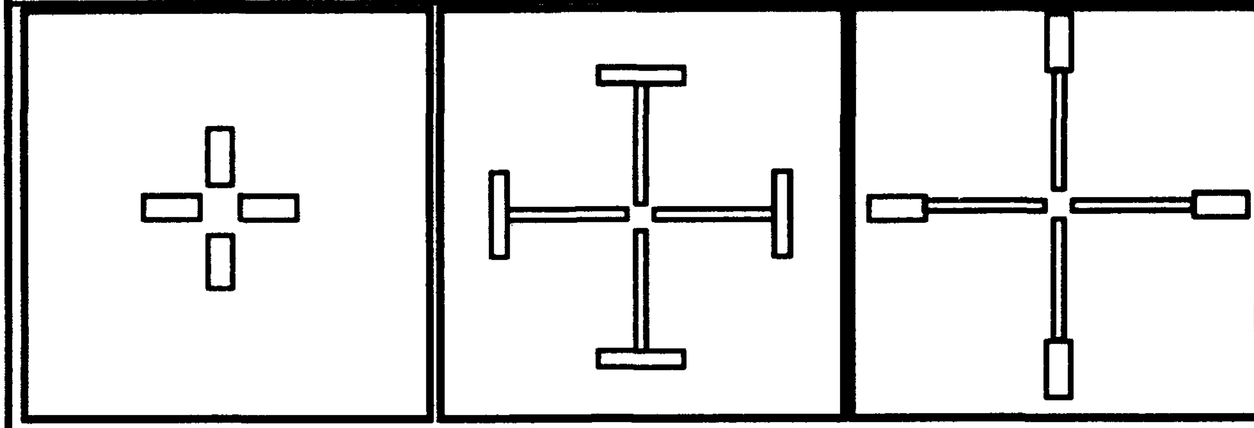
Comments: ______________________________________________

7. Please rate the **overall effectiveness** of each cursor type for designating aim points.

| Cursor 1 | Cursor 2 | Cursor 3 |
|---|---|---|
| ☐ 1. Very ineffective | ☐ 1. Very ineffective | ☐ 1. Very ineffective |
| ☐ 2. Somewhat ineffective | ☐ 2. Somewhat ineffective | ☐ 2. Somewhat ineffective |
| ☐ 3. Average | ☐ 3. Average | ☐ 3. Average |
| ☐ 4. Somewhat effective | ☐ 4. Somewhat effective | ☐ 4. Somewhat effective |
| ☐ 5. Very effective | ☐ 5. Very effective | ☐ 5. Very effective |

Comments: ______________________________________________

| CURSOR 1 | CURSOR 2 | CURSOR 3 |
|---|---|---|



8. Which cursor provided the **best overall performance?**

☐ Cursor 1 ☐ Cursor 2 ☐ Cursor 3

8a. Why? ______________________________

9. **How** would you improve upon the cursor listed in question 8 (the best performing cursor) and **why** do you consider this an improvement? ______________________________

**B. Designation Technique**

1. Describe the overall technique you used for crosshair positioning and designating aim points during the demonstration.

Cursor 1: ______________________________

Cursor 2: ______________________________

Cursor 3: ______________________________

## C. Mechanization

The following questions address the **mechanization** characteristics of the cursor (regardless of cursor type).

1. In terms of designation speed and accuracy, how would you rate the difficulty of controlling the cursor position?

- ☐ 1. Very difficult
- ☐ 2. Somewhat difficult
- ☐ 3. Average
- ☐ 4. Somewhat easy
- ☐ 5. Very easy

2. How would you change the control mechanism to improve crosshair positioning?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

## SECTION 3: EVALUATION OF PART-TASK SIMULATION

This section contains questions about the realism of the part-task simulation. We are interested in your comments regarding quality of the simulated SAR imagery, the procedure used to accomplish the radar updates, the mechanization of the cursor, and the quality of the RFP cards.

### A. Realism/Quality of SAR Imagery

1. Overall, how would you rate the realism of the simulated SAR imagery presented during the demonstration?

- ☐ 1. Very unrealistic
- ☐ 2. Somewhat realistic
- ☐ 3. Very realistic
- ☐ 4. Don't know

2. What simulated SAR effects/characteristics would you improve?

____________________________________________

____________________________________________

____________________________________________

____________________________________________

3. Do you feel the types (tanks, bridges, buildings, towers, etc.) selected for the demonstration are typical of those you experience in your operational units?

- ☐ Yes
- ☐ No
- ☐ Don't know

3.a. If not, why?

____________________________________________

____________________________________________

____________________________________________

4. As you know, the levels of CONTRAST and BRIGHTNESS were preset for the simulated SAR imagery. Rate the selected settings in terms of desirability.

- ☐ 1. Poor
- ☐ 2. Average
- ☐ 3. Good

Explain: ______________________________

______________________________

______________________________

______________________________

**B. Radar Update Procedure**

1. How effective was the demonstration in simulating the procedure used for performing radar updates?

- ☐ 1. Very ineffective
- ☐ 2. Somewhat ineffective
- ☐ 3. Average
- ☐ 4. Somewhat effective
- ☐ 5. Very effective
- ☐ 6. Don't know

Explain: ______________________________

______________________________

______________________________

**C. Mechanization of the Cursors**

1. How effective was the demonstration in simulating the mechanization of the cursor?

- ☐ 1. Very ineffective
- ☐ 2. Somewhat ineffective
- ☐ 3. Average
- ☐ 4. Somewhat effective
- ☐ 5. Very effective
- ☐ 6. Don't know

Explain: ______________________________

______________________________

______________________________

## D. Realism of the RFP Cards

1. Rate the realism of the RFP cards used during the demonstration.

   ☐ 1. Very unrealistic

   ☐ 2. Somewhat realistic

   ☐ 3. Very realistic

   ☐ 4. Don't know

Explain: ______________________________________________

______________________________________________

______________________________________________

# APPENDIX C

## Questionnaire and Debrief Results

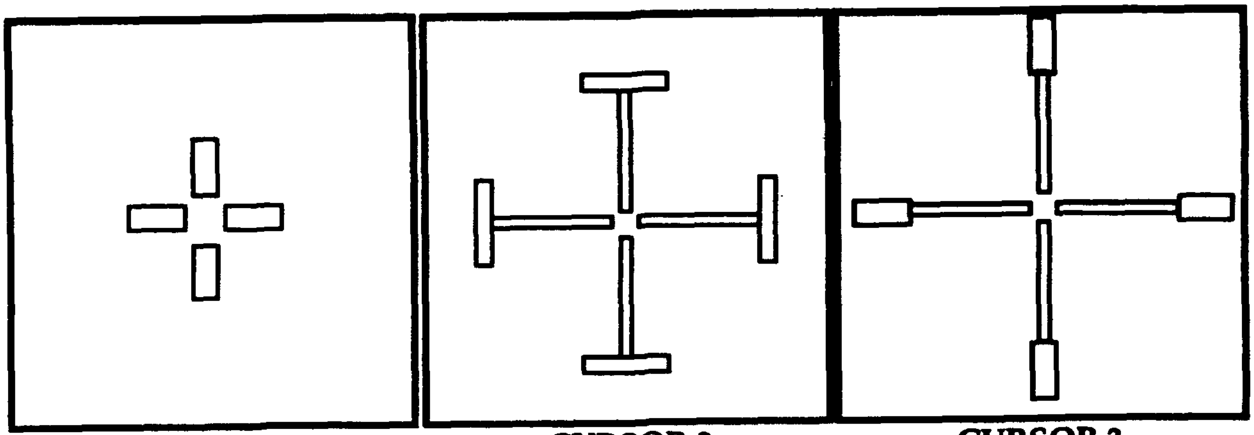
## SECTION 1: BIOGRAPHICAL DATA

Summary of Biographical Data for 18 Subjects

| AIRCRAFT TYPE | POSITION | SENSOR | EXPERIENCE OPERATING CROSSHAIR |
|---|---|---|---|
| B-2 = 2<br>B-1 = 8<br>B-52 = 13<br>*Other = 6 | OSO = 7<br>WSO = 2<br>RN = 8<br>NAV = 7<br>Pilot = 1<br>EW = 3 | SAR = 9<br>EVS/FLIR = 14 | 17 |

*Other aircraft types included F-15, F-11, F-4, F-16, and/or KC-135

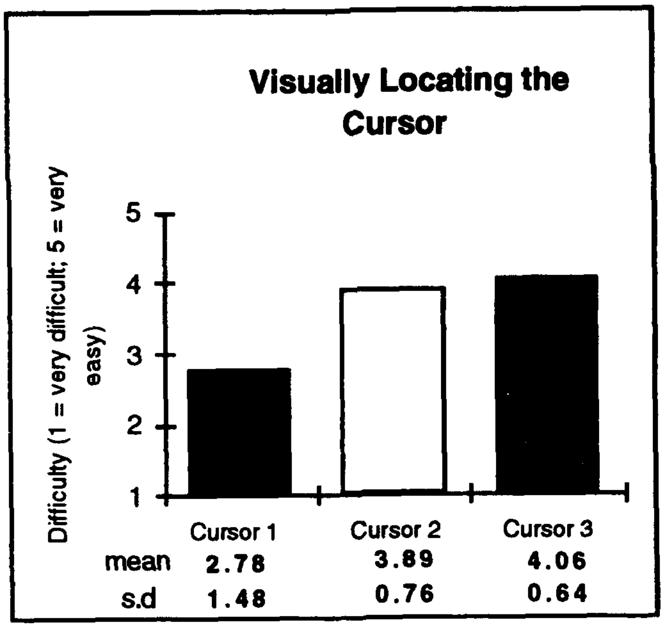
## SECTION 2: EVALUATION OF THE CURSOR



CURSOR 1 CURSOR 2 CURSOR 3

### 2A. Cursor Type

**2A-1. In general, visually locating or seeing the cursor.**

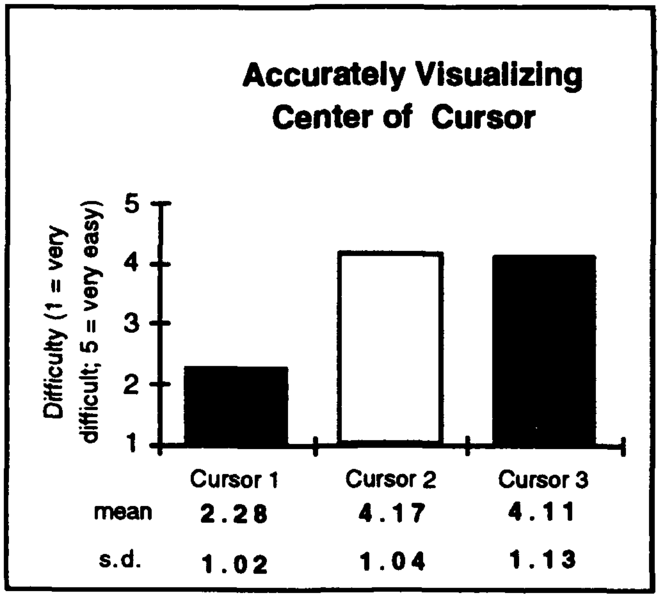



**2A-1. Subjects' Comments**

| Subject # | Comments |
|---|---|
| S1 | - Cursor 1 was easier to see than Cursors 2 and 3. |
| S2 | - Cursor 1 was obscured in the light (bright) return, and it made it difficult to see exactly where the center of the cursor was. |
| S3 | - Cursor 1 was somewhat difficult because it got buried in the background.<br>- Cursor 2 was the easiest because of the perpendicular end points. |
| S4 | - Cursor 1 was somewhat difficult when it appeared over bright terrain. |

| | |
|---|---|
| S5 | - Cursor 1 was somewhat difficult, particularly when there was a lot of blooming. The cursor got lost in the background sometimes. |
| S6 | - Cursor 1 was difficult to locate in a cluttered environment. |
| | - The perpendicular end points on Cursor 2 helped me find it. |
| S9 | - Cursor 3 was the easiest to find because of end bars and large size. |
| S10 | - Cursor 1 got lost in the bright or light returns. Cursor 3 was the easiest. |
| S11 | - Cursor 1 was easiest to locate; others were somewhat easy to locate. |
| S12 | - Cursor 1 was more difficult because of the width of the bars (i.e., brightness). |
| | - Cursors 2 and 3 were easier because of the long bars. They don't tend to get buried in bright returns. |
| S13 | - Cursor 1 was difficult in a high gain or large return environment. I found myself moving off when such an environment existed. Cursor 3 was the easiest to see because of the large end points. |
| S14 | - Cursor 1 was difficult because it blends in with high returns. Cursor 3 was the easiest to pick out from the background. |
| S15 | - Cursor 1 was difficult because it looked like a return. |
| S16 | - Cursor 1 was easiest to see because it was so bright. |
| S18 | - Cursor 2 was easiest to see because of end points. |

**2A-2. Accurately visualizing the center of the cursor intersection.**

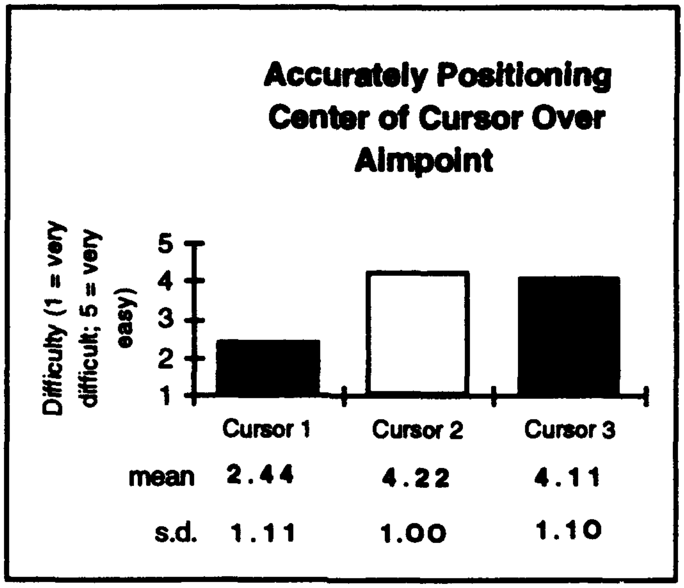



**2A-2. Subjects' Comments**

| Subject # | Comments |
|---|---|
| S1 | - Cursor 1 was somewhat difficult because the bars are too wide |
| | - Cursors 2 and 3 were easier because of narrower bars. |
| S2 | - Cursors 1 and 3 got lost in the white areas of the presentation. |
| S3 | - Cursor 1 was difficult because of the fatness of the bars. |

| | |
|---|---|
| S4 | - It was very easy to see Cursors 2 and 3 because the lines were very thin. |
| | - Cursor 1 was more difficult because of the thickness or wideness of arms. |
| S5 | - Cursor 1 was somewhat difficult because of the thickness of the bars. |
| S6 | - I didn't like the small opening of Cursor 2. |
| S7 | - Cursor 1 was more difficult because of the width of the bars and large center opening. |
| S8 | - Cursor 1 was difficult because of its large opening. |
| S9 | - Cursor 1 was difficult because of its brightness and boldness. |
| S10 | - Cursor 1 was somewhat difficult; Cursors 2 and 3 were both easy. |
| S11 | - Cursor 1 was more difficult. |
| S12 | - I believe I'm less accurate with Cursor 1 because of the wide bars; I can't line up as well. |
| | - It was easier to visualize the center with Cursors 2 and 3 because of the fine lines. |
| S13 | - Cursor 1 was difficult because of the wideness of the bars. Cursors 2 and 3 were both easy. |
| S14 | - Cursor 1 was the easiest because of the large opening. |
| S15 | - Cursor 1 was very difficult because of the width of the bars. |
| S16 | - I liked the larger opening of Cursor 1. Cursor 3 was very easy because the end bars led your eye into the center intersection. |
| S17 | - Cursor 1 obscured the fix point. |
| S18 | - Because I lined up one axis at a time, Cursors 2 and 3 made that easy. I couldn't do that with Cursor 1. |

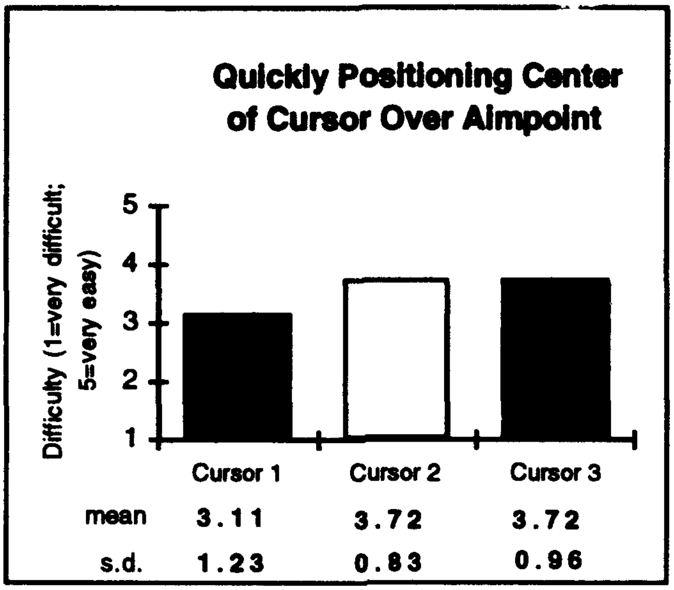
**2A-3. Accurately positioning the center of the cursor over the desired designation point.**




**2A-3. Subjects' Comments**

| Subject # | Comments |
|---|---|
| S1 | - This gets into the problem of mechanization. I object to the fact that I can't move diagonally. |
| | - Cursor 1 had an additional step to move off the area; then begin positioning. |
| S2 | - Cursor 2 was the definite favorite because the others got lost in white areas of return. |
| S3 | - All cursors were difficult because of the crosshair control. |
| S5 | - Cursor 2 was the easiest. |
| S7 | - All cursors were downgraded because of the cursor control. Mechanization made an easy task difficult. |
| S8 | - Cursor 1 was difficult because of its large opening. |
| S9 | - Cursor 1 was difficult because of its brightness and boldness. |
| S10 | - Cursor 1 was somewhat difficult; Cursors 2 and 3 were both easy. |
| S11 | - Cursor 1 was difficult because of the coarseness of the bars. |
| S12 | - I believe I'm less accurate with Cursor 1 because of the wide bars; I can't line up as well. |
| | - It was easier to visualize the center with Cursors 2 and 3 because of the fine lines. |
| S13 | - Cursor 1 was difficult because of the wideness of the bars. Cursors 2 and 3 were both easy. |
| S14 | - I didn't like the small opening of Cursors 2 and 3. |
| S17 | - I felt Cursor 1 degraded accuracy. I felt handicapped because of the coarseness of the design. |

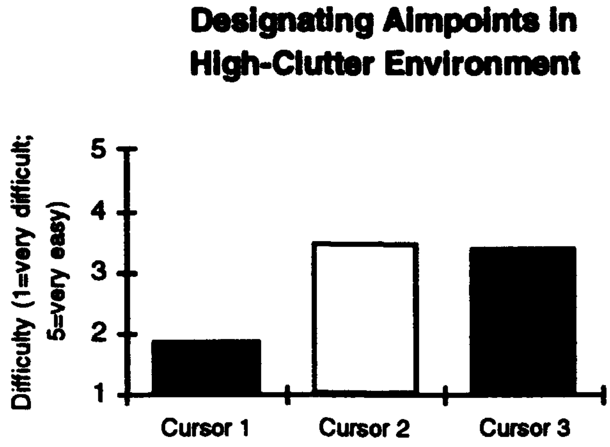
**2A-4. Quickly positioning the center of the cursor over the desired designation point.**




**2A-4. Subjects' Comments**

| Subject # | Comments |
|---|---|
| S1 | - Cursor 1 gross and fine positioning were very slow. Cursors 2 and 3 gross positioning was fine; but fine positioning was difficult because of mechanization. Cursor 3 was a little harder because of the wide end bars. End bars were a little distracting on Cursor 3. |
| S2 | - Cursor 1 failed miserably in all areas. |
| S3 | - Cursor 1 was difficult because it obscured what was in the background and that impacted my speed. |
| S5 | - Cursor 2 was easiest. |
| S7 | - Cursors 2 and 3 were easier than Cursor 1 because of narrower bars. |
| S9 | - Cursor 1 was difficult because of its brightness and boldness. |
| S12 | - Cursor 1 seems the fastest, but I question my accuracy. |
| S13 | - The length of Cursors 2 and 3 helped me in terms of speed. |
| S14 | - Cursor 1 was easiest because of the large opening. |
| S15 | - Cursor 1 was the most difficult because I always had to move off to see what was underneath. Cursor 3 was the easiest. |
| S18 | - Cursor 1 had to be moved out of the way before starting to position; wasted time. |

**2A-5. Designating aim points in a high-clutter environment.**



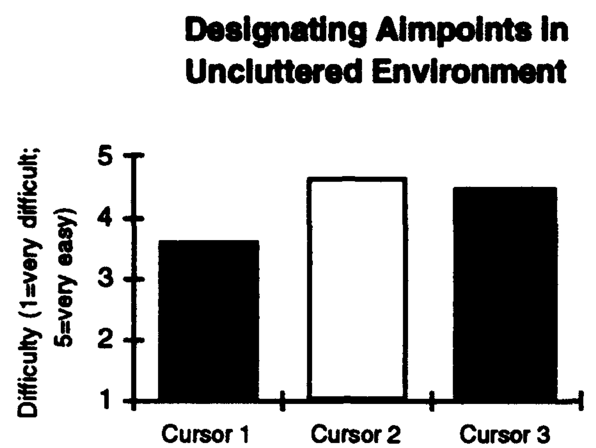

| | Cursor 1 | Cursor 2 | Cursor 3 |
|---|---|---|---|
| mean | 1.83 | 3.44 | 3.39 |
| s.d. | 1.04 | 1.04 | 0.92 |

**2A-5. Subjects' Comments**

| Subject # | Comments |
|---|---|
| S1 | - Cursor 1 was difficult in a cluttered environment because it obscured everything in the area of interest.<br>- Cursor 2 long bars helped me line up past bright returns in the area of interest. I would like to see a larger opening on Cursors 2 and 3. |
| S4 | - Brightness of Cursor 1 makes it difficult in images with bright return.<br>- Length of Cursors 2 and 3 made it easier. |
| S5 | - Cursor 1 was difficult because it obscured the area of interest. |
| S6 | - Because of the width of Cursor 1, it appeared brighter than many of the returns. It also obscured things. |
| S7 | - Cursor 1 was somewhat difficult because of the width and shortness of the bars. |
| S8 | - Because of high reflectivity, Cursor 1 was blanked out at times.<br>- Cursors 2 and 3 are a little easier because of the length of the cursors, but it is still difficult to center over the exact "golden pixel". |
| S10 | - Cursor 1 was difficult because of the bright video surrounding it. Cursor 3 was the best in high clutter. |
| S12 | - When it's bright you can't find Cursor 1. Very difficult. |
| S13 | - Cursor 1 was very difficult in high clutter. Cursor 3 was easier than Cursor 2 because of end points. |
| S14 | - Cursor 1 was easiest because of its large opening. |
| S15 | - Cursor 1 was the most difficult because it blended in with returns. |
| S16 | - Cursor 3 was the easiest because of the end points. |
| S17 | - Cursor 1 was very difficult because it washed out when near or over other returns. |

S18 - Cursor 1 was more difficult than the others.

## 2A-6. Designating aim points in an uncluttered environment

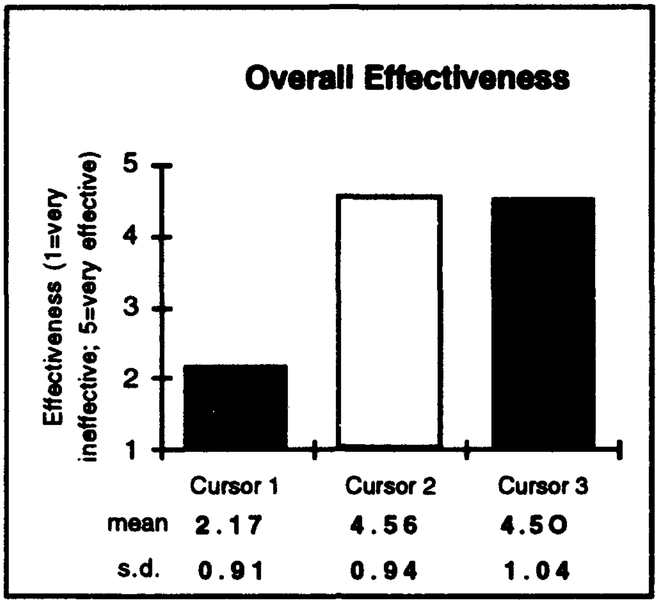



| | Cursor 1 | Cursor 2 | Cursor 3 |
|---|---|---|---|
| mean | 3.61 | 4.61 | 4.44 |
| s.d. | 1.24 | 0.61 | 0.70 |

## 2A-6. Subjects' Comments

| Subject # | Comments |
|---|---|
| S4 | - The lengths of Cursors 2 and 3 made it very easy to designate in uncluttered environments. |
| S9 | - All cursors were easy. |
| S11 | - All cursors were easy. |
| S12 | - All the cursors were easy when there were no bright returns. |
| S13 | - Cursor 1 was most difficult because of the wideness of bars. I liked Cursor 2 in an uncluttered environment. |
| S14 | - All cursors performed the same in uncluttered environment. |
| S16 | - All cursors were easy. |
| S18 | - All cursors were easy. |

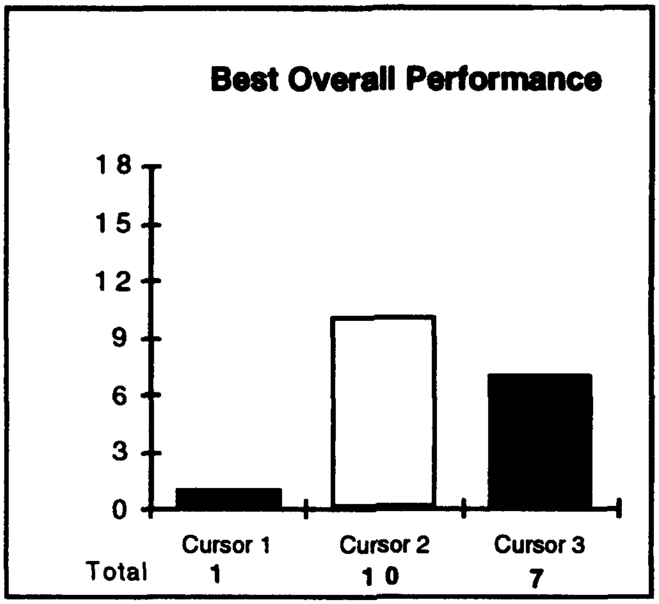
**2A-7. Please rate the overall effectiveness of each cursor type for designating aim points.**




**2A-7. Subjects' Comments**

| Subject # | Comments |
|---|---|
| S1 | - Cursor 1 was ineffective because of its overall size and width of the bars. |
| | - Cursor 2 was most effective because of its overall size, narrow bars and end points. |
| S2 | - Cursor 2 was the clear favorite for me. |
| S4 | - Cursor 2 was very effective. I didn't like Cursor 3 as well, but I am not sure why. |
| | - Cursor 1 was ineffective because of shortness and thickness of bars. |
| S5 | - Cursor 1 was the worst; Cursor 2 was the best. |
| S6 | - Cursor 1 was most difficult to find. It covered things up. |
| S8 | - Cursors 2 and 3 were easier in terms of designating accurately. |
| S9 | - Cursor 3 was the best because of the end points. |
| S10 | - Cursor 1 was very ineffective; Cursor 3 is very effective because of the longer legs that lead into the center. |
| S11 | - Cursor 3 was the most effective because of end points; these made it easy to find it and move it into the area of the aim point. I didn't like the narrow end points on Cursor 2. |
| S12 | - Cursor 1 was somewhat effective. |
| S13 | - Cursor 3 was most effective. |
| S15 | - Cursor 1 was ineffective; I thought both Cursors 2 and 3 were very effective. |
| S16 | - Cursor 3 was the most effective. |
| S17 | - Cursor 1 was very ineffective because I felt my accuracy was compromised. |
| S18 | - Cursors 2 and 3 were very effective. |

**2A-8. Which cursor provided the best overall performance?**




**2A-8a. Why?**

| Subject # | Comments |
|---|---|
| S1 | - I liked Cursor 2 the best because of its narrow arms; the terminators helped me find the cursor and line up for designating. I also thought the terminators on Cursor 3 were a little too wide. |
| S2 | - Cursor 2 was the easiest to position over the target. I liked the larger size for lining up. |
| S4 | - Cursor 2 performed the best because of the vertical bars at the end. Cursor 3 end bars might obscure in some situations. |
| S5 | - Cursor 2 was the easiest to locate because of vertical terminators. I had an easier time visualizing the intersection of cursor. |
| S6 | - I liked Cursor 2 because of the perpendicular terminators and small width of crosshairs. I would like to see the cursor even bigger, like on the B-1. |
| S7 | - I liked Cursor 2 because of the light contrast between it and surrounding display; large enough size; and thinness of the bars. |
| S8 | - I liked Cursor 2 because I could designate faster . It also pruvided the most detail and provided the best accuracy. |
| S9 | - I liked Cursor 3 because of the thinness of the inside and wideness of the outside end points. |
| S10 | - I liked Cursor 3 because of the longer arms that lead into the center. |
| S11 | - I liked Cursor 3 the best because of the end points and large size. |
| S12 | - The bars on the ends of Cursor 2 made it slightly easier for me to find and to aim. |
| | - I liked how small the center opening is on Cursors 2 and 3. |

| | |
|---|---|
| S13 | - I liked Cursor 3 because the fatter end points helped over a wide range of gain and contrast settings. The smaller opening is an improvement. Also, the longer and narrower lines pointing to the center was a big help. |
| S15 | - I liked Cursor 2 because of perpendicular end points. |
| S16 | - I liked Cursor 3 because of its outer border; it was good for gross positioning and the thinner bars were good for fine positioning. |
| S17 | - I liked Cursor 3 because it was easy to acquire, contrast in the high and low clutter; I used the fat part to initially acquire, then the fine lines for fine positioning. In my opinion, Cursor 3 provides the best of both worlds. |
| S18 | - I liked Cursor 3 because of the longer bars. |

**2A-9. How would you improve upon the cursor listed in question 8 (the best performing cursor) and why do you consider this an improvement?**

| Subject # | Comments |
|---|---|
| S1 | - Increasing the size of the opening would be an improvement on Cursor 2. |
| S2 | - Have cursor a different color than the screen. |
| S3 | - A dashed line for Cursor 2, which will get smaller as you get to the center. |
| S4 | - From my B-1B experience, make the cursor longer. |
| S5 | - Cursor 2 is already very effective. No suggestions. |
| S6 | - Cursor 2 makes the center larger. Needs a capability to tune intensity of cursor. |
| S7 | - Improvement to Cursor 2: It's a little large to take advantage of cardinal effect, and as cross reference to larger field of view (i.e., surrounding aim points). |
| S8 | - Improvement to Cursor 2: Allow for changing the color of the cursor in order to provide contrast between cursor and background image. Smart cursor or auto/manual contrast. |
| S10 | - Improvement to Cursor 3: Make the end points blink; this would be helpful in a stressful, bumpy environment. |
| S14 | - Improvement to Cursor 1: Change the color or use multiple sizes of cursors. |
| S15 | - Improvement to Cursor 2: Make the crosshairs even longer. |
| S16 | - Improvement to Cursor 3: Make the center opening larger. |
| S17 | - Improvement to Cursor 3: Capability to select reverse video or flashing cursor so I can maximize the contrast between cursor and background. |

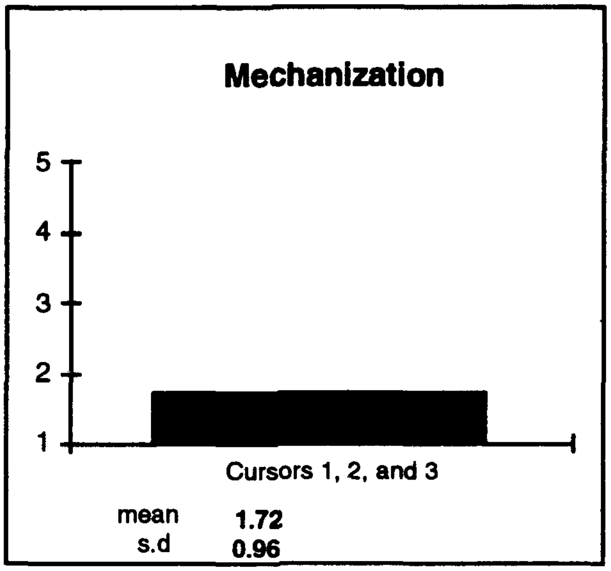
## 2B. Designation Technique

**2B-1. Describe the overall technique you used for crosshair positioning and designating aim points during the demonstration.**

| Subject # | Comments |
|---|---|
| S1 | - Cursor 1 required an extra step in that you had to move the cursor off the image in order to see what was underneath. Other than that, I used the same strategy for all cursors. |
| S2 | - I used the same strategy for Cursors 1 and 2. Lined up one axis at a time for Cursor 3. |
| S3 | - I used the same technique for Cursors 2 and 3. Had to move cursor off with Cursor 1. |
| S4 | - I had to move Cursor 1 off the area of interest. Cursor 1 obscured aim points. |
| S5 | - I moved Cursor 1 off in order to see area of interest. Moved one axis at a time. I used direct placement for Cursors 2 and 3. |
| S6 | - I had to move Cursor 1 out of the way initially, but didn't have to move Cursors 2 and 3. Other than that I used the same technique. |
| S7 | - I used an additional step for Cursor 1, which was to move the cursor off in order to see area of interest. |
| S8 | - I used the same technique for Cursors 2 and 3: one axis at a time. Used ends of cursors to line up. |
| S9 | - I used the same technique for all three cursors. |
| S11 | - I used the same technique for all but I felt I had the ability to perform fine positioning with Cursors 2 and 3. |
| S10 | - Cursor 1 required that I had to guess where the golden pixel was positioned. I used the same technique with Cursors 2 and 3, but felt I was more accurate because of the small opening. |
| S12 | - I used thin bars of Cursors 2 and 3 to line up one axis at a time. |
| S13 | - Cursor 1 was pulled off initially to see the aim point. It was particularly difficult to use in high gain settings. I found with all cursors that I settled for being "close enough" because of mechanization. Cursors 2 or 3 were able to be moved right to the aim point, then lined up one axis at a time. |
| S14 | - Cursor 1 required an extra step of moving off the aim point to see what was underneath. |
| S15 | - There was an extra step with Cursor 1 of pulling the cursor off to see underneath. For Cursors 2 and 3 I lined up one axis at a time. |
| S17 | - Cursor 1 required an extra step in that you had to move the cursor off the image in order to see what was underneath. |
| S18 | - Cursor 1 required an extra step in that you had to move the cursor off the image in order to see what was underneath. Other than that I used the same strategy for all cursors. |

## 2C. Mechanization

**2C-1. In terms of designation speed and accuracy, how would you rate the difficulty of controlling the cursor position?**




**2C-2. How would you change the control mechanism to improve crosshair positioning?**

| Subject # | Comments |
|---|---|
| S1 | - I could not move diagonally. Gross movement is fine, particularly with Cursors 2 and 3. Fine positioning is very difficult. Mechanization causes the cursor to jump past the desired designation point. Also, with Cursor 1 there is an additional motion in that you have to move the cursor off in order to see what it is covering. |
| S1 | - Would improve by: (1) decreasing deadband, (2) removing residual motion, (3) improving diagonal control, and (4) modifying slew curve for fine positioning. |
| S2 | - I had trouble moving one pixel at a time. I would like to be able to lock position in on one axis at a time. |
| S3 | - It was okay for gross positioning but awful for fine positioning. I would have two separate modes. Fine positioning would be a slower movement (maybe use a trackball). |
| S4 | - I had difficulty performing fine positioning for all cursors. I had to bump and then did a lot of overshooting. I would recommend two mechanization rates; one for gross and one for fine positioning. It would then allow for fast movement and slow movement for precise positioning. |
| S5 | - Need a two rate mechanization; fast and slow rates. I also think a trackball is easier to use than the slew button. |
| S6 | - I had to put too much pressure on thumb position. Something needs to be accomplished in order to eliminate overshooting. I didn't like the |

hardware; pull trigger to activate, then release to designate. I didn't like the slew curve

S7 - It was okay for gross positioning; very difficult for fine positioning. I didn't like the fact that I couldn't move it diagonally. This kept me from designating the pixel I wanted and also impeded accuracy.

S8 - Mechanization very much like the aircraft - very difficult. It takes too much pressure to move the cursor. Need to readjust slew rate to make the fine positioning easier.

S9 - Stiff controls made it difficult for fine positioning (i.e., cursor jumped past where I wanted to be). Increase the amount that you can move the button; also use a variable rate.

S10 - Control would go past where I wanted to go. Couldn't move it one pixel at a time. In a low level, turbulent environment it would be very difficult. I would like constant velocity. Cursor should stop immediately, but it seemed to keep running past where I wanted to go.

S11 - Completely unsatisfactory. Movement was not proportional to force applied. An improvement would include decreasing the deadband. I would like the control itself to move more to provide better feedback.

S12 - Mechanization is awful. I didn't like the thumb controller. The fine positioning is very difficult. Suggest looking at the hardware itself, the slew rate curve (lower the slope on the rate), and the deadband (too big?).

S13 - Mechanization was very difficult, particularly in fine positioning. There is a lot of bumping. Cursors 2 and 3 helped because of narrow lines. Changes: didn't seem to act the same each time with similar pressure (was too jerky). I couldn't find the sensitive spot (always tapping).

S14 - It was difficult because I felt the rate was unpredictable. Changes would include operator being able to change the slew rate.

S15 - It was very difficult because of the jumping of the cursor. It would be particularly difficult in a turbulent environment. It didn't seem to move one pixel at a time. I would like to see greater movement on the slew button to provide feedback.

S16 - I felt the cursor was responsive but also would jump past where I wanted to be at times. Possibly change to a thumb trackball or something that is easier to move back and forth.

S17 - The mechanization is very difficult. This is the number one thing to change. I would want to be able to move the cursor 1-2 pixels at a time. Awful for fine positioning.

## SECTION 3: EVALUATION OF PART-TASK SIMULATION

### 3A. Realism/Quality of SAR Imagery

**3A-1. Overall, how would you rate the realism of the simulated SAR imagery presented during the demonstration?**

| NUMBER OF RESPONDENTS | MAXIMUM REALISM RATING | MEAN | STANDARD DEVIATION |
|---|---|---|---|
| 17 | 3 | 2.67 | .61 |

**3A-2. What simulated SAR effects/characteristics would you improve?**

| Subject # | Comments |
|---|---|
| S5 | - Overall, the best I've seen in a simulator. |
| S6 | - Shadowing on peaks could have been improved. |
| S11 | - Pixels were too large and too grainy. Shadowing was unrealistic. |
| S12 | - Good job on imagery. |
| S15 | - Didn't seem to be an adequate amount of shadowing of buildings and silos. |

**3A-3. Do you feel the types (tanks, bridges, buildings, towers, etc.) selected for the demonstration are typical of those you experience in your operational units?**

| NUMBER OF RESPONDENTS | POSSIBLE RATINGS | RESPONSES |
|---|---|---|
| 17 | YES/NO/DON'T KNOW | 100% = Yes |

**3A-3a. If not, why not?**

| Subject # | Comments |
|---|---|
| S1 | - "Southwest end of ridge line" and "end of butte" are not realistic aim points for SAR. |
| S8 | - Might want to include some intersections of runways. |
| S9 | - I wouldn't use terrain features for SAR (top of the mountain, butte). |
| S11 | - Good selection of aim points. |
| S12 | - Terrain is not good for SAR. |

**3A-4. As you know, the levels of CONTRAST and BRIGHTNESS were preset for the simulated SAR imagery. Rate the selected settings in terms of desirability.**

| NUMBER OF RESPONDENTS | MAXIMUM DESIRABILITY RATING | MEAN | STANDARD DEVIATION |
|---|---|---|---|
| 18 | 3 | 2.44 | .62 |

**3A-4. Subjects' Comments**

| Subject # | Comments |
|---|---|
| S5 | - Need to be able to adjust to reduce the blooming. |
| S6 | - Tune down, especially with no cursor contrast control. |
| S8 | - Edges of ridges imagery was too bright and I needed to tone them down. Terrain returns needed the most work. |
| S12 | - An overall good job, although I didn't like the fact that it was fixed. |
| S13 | - Lower gain setting and brightness would have helped to ID the cursor earlier. |

**3B. Radar Update Procedure**

**3B-1. How effective was the demonstration in simulating the procedure used for performing radar updates?**

| NUMBER OF RESPONDENTS | MAXIMUM EFFECTIVENESS RATING | MEAN | STANDARD DEVIATION |
|---|---|---|---|
| 16 | 5 | 4.44 | 1.03 |

**3B-1. Subjects' Comments**

| Subject # | Comments |
|---|---|
| S8 | - Procedure didn't include all the procedural stuff that the operator can do to perform a good update. (changing patch sizes, adjusting brightness and contrast controls) |
| S15 | - I didn't like the time pressure. Never seemed to be time pressure in operational environment (B-1). |

## 3C. Mechanization of the Cursors

### 3C-1. How effective was the demonstration in simulating the mechanization of the cursor?

| NUMBER OF RESPONDENTS | MAXIMUM EFFECTIVENESS RATING | MEAN | STANDARD DEVIATION |
|---|---|---|---|
| 8 | 5 | 4.5 | 1.19 |

### 3C-1. Subjects' Comments

| Subject # | Comments |
|---|---|
| S8 | - This shows how awful the mechanization is in the actual aircraft. |

## 3D. Realism of the RFP Cards

### 3D-1. Rate the realism of the RFP cards used during the demonstration.

| NUMBER OF RESPONDENTS | MAXIMUM REALISM RATING | MEAN | STANDARD DEVIATION |
|---|---|---|---|
| 15 | 3 | 2.60 | .51 |

### 3D-1. Subjects' Comments

| Subject # | Comments |
|---|---|
| S8 | - Cards were fuzzier than the actual cards. |
| S11 | - The description of aim points could have been improved and the quality of the photographs was dismal. |
| S15 | - I didn't like the digitized image. |



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